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National Bureau of Standards Mass Calibration Computer Software

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National Bureau of Standards Mass Calibration Computer Software

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National Bureau of Standards Mass Calibration

Computer Software

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This report describes the FORTRAN computer program used to generate a comprehensive report covering the sequence of operations used to assign mass values to weights submitted to the National Bureau of Standards for calibration. The assignment of these values is accomplished by the method of least squares analysis of the observation of differences between test items and reference items having the same or nearly same density and nominal size. The calculations are defined and the various weighing method options are given. To assist the user, a detailed description of the input data, an input list of error messages, a listing of a sample test case and a listing of the output resulting from the use of the sample test case are given. To assist in the implementation of the computer program, a flow chart, a description of each subprogram, a cross-reference of labeled COMMON, a list of DOUBLE PRECISION variables, a list of EQUIVALENCED variables and other pertinent information is given.

Key words: Calibration report; correction to mass measurements; error checking; FORTRAN program; least squares solution; mass calibration; mass measurements.

1.0 Introduction

This report describes the FORTRAN computer program used to generate a comprehensive report covering the sequence of operations used to assign mass values to weights submitted to the Nationl Bureau of Standards for calibration. The assignment of these values is accomplished by the least squares analysis of the observation of differences between test items and reference items having the same or nearly same density and nominal size. The calculations are defined and the various weighing method options are given. To assist the user, a detailed description of the input data, a list of error messages, a listing of a sample test case and a listing of the output resulting from the use of the sample test case are given. To assist in the implementation of the computer software, a flow chart, a description of each subprogram, a cross-reference of labeled COMMON, a list of DOUBLE PRECISION variables, a list of EQUIVALENCED variables and other pertinent information is given.

2.0 Calculations

This section describes in detail the calculations used by the computer software to assign mass values to weights which have been submitted for calibration. For a discussion of the philosphy of the procedures used, see references [1,2,6,8]. Section 2.1 lists the definition of the symbols used and their corresponding FORTRAN variable names. The use of || in this section denotes the absolute value of the enclosed quantity. The use of [] denotes a matrix operation with the exception of the mentioning of a reference. The use of ' denotes the transpose of a vector or matrix. Most, but not all, of the calculations described in this section are performed by the MAIN program.

The average temperature, humidity and pressure are determined from values taken before and after each set of measurements. Because the instruments used to measure these environmental conditions may change with each weighing, the appropriate instrumental correction to the temperature, humidity and pressure are given with each set of weighings as follows:

$$\overline{T} = (T_1 + C_{T1} + T_2 + C_{T2})/2$$

$$\overline{H} = (H_1 + C_{H1} + H_2 + C_{H2})/2$$

$$\overline{P} = (P_1 + C_{P1} + P_2 + C_{P2})/2$$

All input weights (nominals) are converted to grams if they are in pounds.

$$W_j = W_j x\ 453.59237 \text{ for } j = 1,\ldots,k$$

Accepted mass correction and the volume of the restraint are computed as follows:

If first series

$$C_R = [V'_1 \tau]$$

$$V_R = [V'_1 B]$$

where $B_j = \dfrac{(W_j + .001\tau_j)}{\rho_j}(1 + \alpha_j \Delta t)$ for $j = 1,\ldots,k$

and where $\Delta t = \overline{T} - T_o$, the difference between observed average temperature and nominal temperature.

If not first series

$$C_R = R_c$$

$$V_R = V_s(1 + S_3 \Delta t)$$

Calculations for Buoyancy Corrections

The air density using the averaged environmental conditions is computed from the equation given by Bowman and Schoonover [3].

$$\rho_A = \frac{0.464746}{T_K}\left(P - 0.00378029(H)(e_s)\right)$$

where

ρ_A = density of air in mg/cm^3

T_K = temperature of air in Kelvin

= temperature of air in degrees Celsius + 273.15

H = Relative Humidity in percent
(i.e. 20% = 20)

P = Barometric Pressure in mm of Mercury

e_s = Saturation Vapor Pressure in mm of Mercury

= Exp(p)/(13.5951 x 9.80665)

$p = -4.7406885 \times Ln(T_K)$

$-6.8982434 \times 10^3 \times T_K^{-1}$

$+0.5938385 \times 10^2$

$-0.5797662 \times 10^{-2} \times T_K$

$+6.2223854 \times 10^{-6} \times T_K^2$

The above series expansion is based on an equation developed by Wexler and Greenspan [9]. Using the above equation three values of air density are computed:

$$\rho_a = f(\overline{T}, \overline{P}, \overline{H})$$

$$\rho_{ab} = f(T_1 + C_{T1},\ P_1 + C_{P1},\ H_1 + C_{H1})$$

$$\rho_{aa} = f(T_2 + C_{T2},\ P_2 + C_{P2},\ H_2 + C_{H2})$$

The air buoyancy correction is also applied to the sensitivity weight in computing the mass/division factor:

$$S^* = S_w - \rho_a S_v(1 + S_c \Delta t)$$

Types of weighings

The following calculations depend upon the type of weighing used. The program has provisions for the following six different types of weighing methods. The values of the input parameters N1 and N2 are designated, in parenthesis, for each method.

1. Single Substitution - one pan (N1 = 2, N2 = 1)
2. Single Substitution - two pan (N1 = 2, N2 = 0)
3. Single Transposition - two pan (N1 = 0, N2 = 0)
4. Double Substitution - one pan (N1 = 3, N2 = 1)
5. Double Substitution - two pan (N1 = 3, N2 = 0)
6. Double Transposition - two pan (N1 = 1, N2 = 0)

The weighing method used depends upon the type of balances and weights available, the requirements of the job at hand and/or the preference of the operator performing the calibrations. In all types of weighing, the observed difference, A-B, where A denotes the unknown weight and B denotes the standard or known weight, and the observed sensitivity, denoted by S, are computed in scale divisions. The drift effect and the left-right effect may or may not be calculated depending upon the type of weighing being used. The following descriptions of each weighing method explain the pertinent calculations.

Single Substitution - one pan balance

Two or three readings are made. The sensitivity weight is not always measured.

$$O_1 = A$$

$$O_2 = B$$

$$O_3 = B+S$$

$$(\hat{A-B}) = O_1 - O_2$$

$$\hat{S} = -O_2 + O_3 \quad \text{if } O_3 \neq 0$$

$$\hat{S} = 0.0 \quad \text{if } O_3 = 0$$

There is no drift or left-right effect computed.

Single Substitution - two pan balance

There are six or nine readings made for each set of A and B weights. The sensitivity weight is not always measured.

$O_1 = A$
$O_2 = A$
$O_3 = A$

} 3 readings are taken as the balance is approaching a stable condition.

$O_4 = B$
$O_5 = B$
$O_6 = B$

} 3 readings are taken as the balance is approaching a stable condition.

$O_7 = B+S$
$O_8 = B+S$
$O_9 = B+S$

} 3 readings are taken as the balance is approaching a stable condition. These 3 readings are sometimes omitted.

$$(\hat{A-B}) = \frac{O_1 + 2xO_2 + O_3}{4} - \frac{O_4 + 2xO_5 + O_6}{4}$$

$$\hat{S} = \left| \frac{0_7 + 2x0_8 + 0_9}{4} - \frac{0_4 + 2x0_5 + 0_6}{4} \right| \text{ if } 0_7,\ 0_8 \text{ and } 0_9 \text{ are given.}$$

$\hat{S} = 0.0$ if 0_7, 0_8 and 0_9 are not included. There is no drift of left-right effect computed.

Single Transposition - two pan balance

There are six or nine readings made for each set of A and B weights. If a sensitivity reading is not taken zeros must be used as input to the program.

0_1, 0_2, 0_3 — With A on one pan and B on the opposite pan, three readings are taken as the balance approaches a stable condition.

0_4, 0_5, 0_6 — Weights A and B are interchanged, three readings are taken as the balance approaches a stable condition.

0_7, 0_8, 0_9 — The sensitivity weight is added to either pan and three readings are taken as the balance approaches a stable condition. These readings may be omitted.

$$(\hat{A-B}) = \frac{1}{2}\left(\frac{0_1 + 2x0_2 + 0_3}{4} + \frac{0_4 + 2x0_5 + 0_6}{4} \right)$$

$$\hat{S} = \left| \frac{0_7 + 2x0_8 + 0_9}{4} - \frac{0_4 + 2x0_5 + 0_6}{4} \right| \text{ if } 0_7,\ 0_8 \text{ and } 0_9 \text{ are given}$$

$\hat{S} = 0.0$ if 0_7, 0_8 and 0_9 are not given

$$\hat{LR} = \frac{1}{2}\left(\frac{0_1 + 2x0_2 + 0_3}{4} + \frac{0_4 + 2x0_5 + 0_6}{4} \right)$$

There is no drift factor computed.

Double Substitution - one pan balance with drift

Four readings are made for each set of A and B weights where:

0_1 = A

0_2 = B

0_3 = B+S

0_4 = A+S

The least square solutions for $(\hat{A-B})$, $\hat{S}$, $\hat{\Delta}$ (drift) are:

$$(\hat{A-B}) = \frac{0_1 - 0_2 - 0_3 + 0_4}{2}$$

$$\hat{S} = \frac{0_1 - 3x0_2 + 3x0_3 - 0_4}{2}$$

$$\hat{\Delta} = \frac{-0_1 + 0_2 - 0_3 + 0_4}{2}$$

There is no left-right effect computed.

The value $\hat{\Delta}$ is based on a 1Δ change in scale readings between each reading.

Double Substitution - two pan balance with drift

A total of 12 readings are made for each set of A and B weights where:

0_1
0_2
0_3

Three readings are taken of weight A as the balance approaches a stable condition.

0_4
0_5
0_6

Three readings are taken of weight B as balance approaches a stable condition.

0_7
0_8
0_9

Three readings are taken of weight B+S as balance approaches a stable condition.

0_{10}
0_{11}
0_{12}

Three readings are taken of weight A+S as balance approaches a stable condition.

$$(\hat{A-B}) = \frac{1}{2}\left(\frac{0_1 + 2x0_2 + 0_3}{4} - \frac{0_4 + 2x0_5 + 0_6}{4} - \frac{0_7 + 2x0_8 + 0_9}{4} + \frac{0_{10} + 2x0_{11} + 0_{12}}{4}\right)$$

$$\hat{S} = \frac{1}{2}\left(\frac{0_1 + 2x0_2 + 0_3}{4} - \frac{3(0_4 + 2x0_5 + 0_6)}{4} + \frac{3(0_7 + 2x0_8 + 0_9)}{4} - \frac{0_{10} + 2x0_{11} + 0_{12}}{4}\right)$$

$$\hat{\Delta} = \frac{1}{2}\left(-\frac{0_1 + 2x0_2 + 0_3}{4} + \frac{0_4 + 2x0_5 + 0_6}{4} - \frac{0_7 + 2x0_8 + 0_9}{4} + \frac{0_{10} + 2x0_{11} + 0_{12}}{4}\right)$$

The value $\hat{\Delta}$ is based on a 1Δ change in scale readings between each reading.

Double Transposition - two pan balance with drift

A total of twelve readings are made for each set of A and B weights where:

0_1, 0_2, 0_3 — With A on one pan and B on the opposite pan, three readings are taken as the balance approaches a stable condition.

0_4, 0_5, 0_6 — With A and B interchanged, three readings are taken as the balance approaches a stable condition.

0_7, 0_8, 0_9 — With the sensitivity weight added to either A or B, three readings are taken as the balance approaches a stable condition.

0_{10}, 0_{11}, 0_{12} — With the sensitivity weight added to the opposite pan from the position of the last 3 readings, 3 readings are taken as the balance approaches a stable condition.

$$(\hat{A-B}) = \frac{1}{4}\left(\frac{0_1 + 2x0_2 + 0_3}{4} - \frac{0_4 + 2x0_5 + 0_6}{4} - \frac{0_7 + 2x0_8 + 0_9}{4} + \frac{0_{10} + 2x0_{11} + 0_{12}}{4}\right)$$

$$\hat{S} = \frac{1}{2}\left|\frac{0_1 + 2x0_2 + 0_3}{4} - \frac{3(0_4 + 2x0_5 + 0_6)}{4} + \frac{3(0_7 + 2x0_8 + 0_9)}{4} - \frac{0_{10} + 2x0_{11} + 0_{12}}{4}\right|$$

$$\hat{\Delta} = \frac{1}{2}\left(-\frac{0_1 + 2x0_2 + 0_3}{4} + \frac{0_4 + 2x0_5 + 0_6}{4} - \frac{0_7 + 2x0_8 + 0_9}{4} + \frac{0_{10} + 2x0_{11} + 0_{12}}{4}\right)$$

$$\hat{LR} = \frac{1}{4}\left(\frac{3(0_1 + 2x0_2 + 0_3)}{4} + \frac{0_4 + 2x0_5 + 0_6}{4} + \frac{0_7 + 2x0_8 + 0_9}{4} - \frac{0_{10} + 2x0_{11} + 0_{12}}{4}\right)$$

The value $\hat{\Delta}$ is based on a 1Δ change in scale readings between each reading.

Preparation of data for least squares analysis

The design matrix is used to compute the load L_i for each observation

$$L_i = \sum_{j=1}^{k} \frac{|X_{ji}|}{2} W_j \quad \text{for } i = 1,\ldots,n$$

and the maximum load

$$L_{max} = \max [L]$$

The values $(\hat{A}-B)$, $\hat{S}$ and $\hat{\Delta}$ are converted from scale divisions to mass units. The following calculations apply to all types of weighings. First the average of the observed sensitivity in scale divisions over all sets of observations which have a constant load is computed.

a. $SUM = \Sigma\, \hat{S}_i$ for $\hat{S}_i \neq 0$ and until L_i changes its value

$\hat{S}_i = S^*/\hat{S}_i$

b. $\overline{D} = SUM/j$

where j = number of non zero values in step a.

c. $S_{mu} = |S^*/\overline{D}|$

d. $Y = \dfrac{(\hat{A}-B)\ S^*}{\overline{D}}$

e. $\Delta_{mu} = \dfrac{\hat{\Delta}\ S^*}{\overline{D}}$

f. Change the sign of S_{mu} and Y if input parameter (N4) indicates a reversed scale.

g. Flag values of

$$\left| \frac{(\hat{A}-B)}{\overline{D}\sqrt{j}} \right| \text{ which are } > .25$$

where $(\hat{A}-B)$ is the observed deflection and $\overline{D}\sqrt{j}$ is the sensitivity deflection.

h. Steps a. - g. are repeated for all observations.

Next, the restraint values for the series is computed. If it is the first series the following are computed:

a. Accepted Correction for restraint

$$R_c = [V'_1 \tau]$$

b. Restraint corrected for environmental condition

$$X^* = [V'_1]\ [\tau - p_a(B)]$$

where B is defined on page 2.

If not first series, the following are computed:

$$\rho_j = (W_j + .001\ R_c)/V_s \text{ for } j=1,\ldots,k \text{ and } V_{1_j} \neq 0$$

$$\alpha_j = S_3 \text{ for } j=1,\ldots,k \text{ and } V_{1_j} \neq 0$$

$$X^* = R_c = \rho_a V_s(1 + S_3\ \Delta t)$$

In general, let E(Y) denote the vector of expected values, let X denote the matrix of coefficients (the design matrix) and let β denote the column vector of parameters to be estimated. Then

$$E(Y) = [X][\beta].$$

Using the matrix of the coefficients from the equations of the expected values, a matrix representing the design and a vector, Y, for the observed values are set up.

The least squares estimates of the parameters are given by the solution of normal equations.

$$[X'X][\beta] = [X'][Y]$$

where X'X is a kxk matrix. To bring the equations to full rank the matrix of normal equations is augmented by a restraint vector denoted by V_1.

Thus:

$$[Z] = \begin{bmatrix} [X'X] & [V_1] & [X'\ Y] \\ [V_1'] & \lambda & X^* \\ 0 & 0 & -1 \end{bmatrix}$$

$\lambda = 1$ if $[V_1] = 0$

$\lambda = 0$ if $[V_1] \neq 0$

For more details on the structure of the above matrix see references [7,10,11]. The inverse of the above matrix [Z] is calculated. Two checks are made to determine the success or failure of the inversion.

1. A check is made for singularity.

2. The maximum value of $[I-ZZ^{-1}]$ should be $\leq .01\,\sigma_w$ where

   I is the identity matrix

   σ_w is the accepted within standard deviation of the process

   Z^{-1} is the inverse of Z.

If either of these tests fail an error message is printed and no further calculations will be made. Control will be sent to the subprogram PRINT2 and no final report will be printed.

If the matrix inversion is successful

$$[Z]^{-1} = \begin{bmatrix} [C] & \vdots & [\hat{\beta}] \\ \cdots\cdots & & \cdots\cdots \end{bmatrix}$$

where: C is the kxk matrix containing the elements of the inverse of matrix of normal equations and $\hat{\beta}$ contains the parameter estimates

The deviations (observed-predicted) are computed. In matrix notation

$$[\delta] = [Y] - [X]\,[\hat{\beta}]$$

with dimensions n x 1, n x 1, n x k and k x 1.

The corrections using the estimated parameter values corrected by the air buoyancy correction are computed. An iterative process is used to minimize the error of the estimated values. The calculations are performed using double precision arithmetic.

$$C1_j = \hat{\beta}_j + \rho_a \left(\frac{W_j}{\rho_j}\right)(1 + \alpha_j \Delta t) \quad \text{for } j = 1,\ldots,k$$

a. $$C2_j = \hat{\beta}_j + \rho_a \left(\frac{W_j + .001\ C1_j}{\rho_j}\right)(1 + \alpha_j \Delta t) \text{ for } j = 1,\ldots,k$$

b. If all $| C2_j - C1_j | < .01\,\sigma_w$ continue calculations.

If the above condition is not true set

$$C1_j = C2_j \quad \text{for } j = 1,\ldots,k$$

and repeat steps a. and b. above for a maximum of 10 iterations. A message is printed regarding the number of iterations required.

Determine value of restraint in terms of nominal values.

$$W_R = [V_1'W]$$

Compute volume of unknowns in terms of the estimated correction produced by the above iteration.

$$V_j = \left(\frac{W_j + .001\ C2_j}{\rho_j}\right)\ (1 + \alpha_j \Delta t) \quad \text{for } j = 1,\ldots,k$$

Estimates of Uncertainty

Initially, the uncertainty for the starting restraint is entered in two parts: zero for the limit to possible effect of random error, and a value, E_s, for the uncertainty of the starting standards. All subsequent uncertainty values are based on two components - one due to the uncertainties in starting standards and the other due to the uncertainties from the balance and design used.

The uncertainty in an individual weight consists of the following two components:

Systematic Error

$$E_j = \left(\frac{W_j}{W_R}\right) E_s \quad \text{for } j = 1,\ldots,k$$

Random Error

$$R_j = \sqrt{(3\sigma_w)^2\ C_{jj} + \left(\frac{W_j}{W_R}\right)^2 (3\sigma)^2 + (3\sigma_T)^2} \quad \text{for } j = 1,\ldots,k$$

where

σ_w is the accepted within standard deviation of the process

C_{jj} are the diagonal elements of the inverse of the matrix of normal equations

3σ is random error affecting the restraint*

σ_T is the accepted between variance of the process

The total uncertainty is the sum of the systematic error and the random error.

$$U_j = E_j + R_j \quad \text{for } j = 1,\ldots,k$$

For the outgoing restraint the corresponding values are

Systematic Error

$$E_o = [V_3' \; E]$$

Random Error

$$R_o = \sqrt{(3\sigma_w)^2 \; [V_3' \; CV_3] + \left(\frac{[V_3' \; W]}{W_R}\right)^2 (3\sigma)^2 + (3\sigma_T)^2}$$

If certain weights are to be used in combination, sets of linear combinations, V_5, may be specified. If this is the case the following calculations are made:

Correction to nominals in linear combination

$$C_\ell = [V_5' \; C2]$$

Systematic error for linear combination

$$E_\ell = [|V_5'|E]$$

Random error for linear combinations

$$R_\ell = \sqrt{(3\sigma_w)^2 \; [V_5' \; C \; V_5] + \left(\frac{[V_5' \; W]}{W_R}\right)^2 (3\sigma)^2 + (3\sigma_T)^2}$$

Total uncertainty for linear combination

$$U_\ell = E_\ell + R_\ell$$

*on the initial restraint, the random error is zero.

Precision control is determined by computing the standard deviation

$$s = \sqrt{\frac{\Sigma\delta^2}{n-k+1}}$$

and comparing this with the accepted standard deviation, σ_w, by computing the F ratio

$$F = s^2/\sigma_w^2$$

and comparing it with the critical value for the F distribution. The critical value for the F distribution is given by

$$F_t = \left(1 - \frac{2}{9(n-k+1)} + 2.32635\sqrt{\frac{2}{9(n-k+1}}\right)^3$$

$$\text{for } (n-k+1) \geq 2$$

$$F_t = 6.64 \text{ for } (n-k+1) = 1$$

If $F > F_t$, a message is printed, on the last page of printout for a series, stating that the process is not in control.

The observed value for the check standard is given by

$$C_c = [V'_2\ C2]$$

The nominal value of the check standard is given by

$$[V'_2\ W]$$

The accepted correction value for the check standard is given by

$$[V'_2\ \tau]$$

The difference between the observed and the accepted value is divided by the standard deviation of the check standard to produce the t-test

value

$$T = \frac{[V_2' \; C2] - [V_2' \; \tau]}{\sigma_c}$$

where

$$\sigma_c = \sqrt{(\sigma_w)^2 [V_2' \; C \; V_2] + \left(\frac{[V_2' \; W]}{W_R}\right)^2 \sigma^2 + (\sigma_T)^2}$$

This value is compared with T_t where

$$T_t = \frac{[V_2' \; E]}{\sigma_c}$$

If $|T - T_t| \geq 3$ a message is printed on the last page of printout for a series stating that the check standard is not in control.

Compute values for the final summary of the report as requested by the input vector V_4.

Apparent mass versus brass in milligrams

$$M_a = \left(\frac{(W + .001 \; C2)\left(1 - \frac{.0012}{\rho}\right)}{1 - \frac{.0012 \; (1 + .000054 \times 20)}{8.4}} - W \right) 1000$$

Mass of weight in grams

$$M_T = W + .001 \; C2$$

Total uncertainty in grams

$$U_f = .001 \; U$$

Volume at 20°C

$$V_f = \frac{W + .001 \; C2}{\rho}$$

Coefficient of expansion

$$C_f = \alpha$$

Apparent mass versus a standard having a density if 8.0 grams/CM3 at 20°C

$$CR_f = \left(\frac{(W + .001\ C2)\ \left(\frac{1 - .0012}{\rho}\right)}{1 - \frac{.0012}{8.0}} - W \right) 1000$$

Set up values to be saved for next series if no errors were made and if another series is requested.

Systematic Error

$$E_s = E_o$$

Random Error

$$3\sigma = R_o$$

$$S_3 = \frac{[V_3'\ S_2]}{[V_3'\ S_1]}$$

where

$$S_1 = \frac{W + .001\ C2}{\rho}$$

$$S_2 = \alpha \left(\frac{W + .001\ C2}{\rho} \right)$$

Compute restraint for the next series.

$$R_c = [V_3'\ C2]$$

Compute volume of restraint for the next series.

$$V_s = [V_3'] \left(\frac{W_j + .001\ C2_j}{\rho_j} \right) \quad \text{for } j = 1,\ldots,k$$

2.1 Dictionary of Symbols and Corresponding FORTRAN Variable Names

The first column contains the symbol used by this documentation. The second column denotes input (I), output (O) or computed value (C). The third column gives the variable name used by computer program. The fourth column gives a brief description of the parameter. The symbols are listed in the order that they are used in the program.

Symbol		FORTRAN Name	Description
	I/O	B1	name or organization
	I/O	B2	address of organization
	I/O	B3	address of organization
	I/O	B4	description of weights being calibrated
	I/O	B5	serial number of set of weights
	I/O	B6	date of report
	I/O	B7	test folder number (used for NBS records of calibrations)
3σ	I	RANERR	3 standard deviation limit for random error affecting the restraint
E_s	I	SYSERR	Systematic error in the restraint
T_o	I	TNOM	nominal temperature
T_1	I	T1P	temperature reading in Celsius at beginning of measurements
T_2	I	T2P	temperature reading in Celsius at end of measurements
P_1	I	P1P	pressure reading in mm of Mercury at beginning of measurements
P_2	I	P2P	pressure reading in mm of Mercury at end of measurements
H_1	I	H1P	humidity reading in percent at beginning of measurements

H_2	I	H2P	humidity readings in percent at end of measurements
C_{P1}	I	CP1	correction to "before" pressure reading in mm of Mercury
C_{P2}	I	CP2	correction to "after" pressure readings in mm of Mercury
C_{T1}	I	CT1	correction to "before temperature reading in Celsius
C_{T2}	I	CT2	correction to "after" pressure reading in Celsius
C_{H1}	I	CH1	correction to "before" humidity reading in percent
C_{H2}	I	CH2	correction to "after" humidity reading in percent
$\overline{T}$	C	TBAR	average corrected temperature in Celsius
$\overline{P}$	C	PBAR	average corrected pressure in mm of Mercury
$\overline{H}$	C	HBAR	average corrected humidity in percent
n	I	NOBS	number of observations ≤ 50
k	I	NUNKN	number of unknowns ≤ 15
σ_w	I	STDEBA	accepted within standard deviation of the process in mg.
S_w	I	SWT	true mass value in mg. of sensitivity weight
S_v	I	VSWT	volume of sensitivity weight in cm^3 at 20°C
S_c	I	CEXSWT	coefficient of expension of sensitivity weight
σ_T	I	VARBAL	accepted between standard deviation of the process in mg.
W	I	ANOM	nominal value of weight in grams or pounds
ρ	I/C	DENSTY	density of weights in g/cm^3 at 20°C

α	I/C	COEFEX	coefficient of expansion of weight
τ	I	ACCVAL	accepted correction of weight in mg.
V_1	I	ARSTIN	vector identifying items in the restraint
V_2	I	ACKSTD	vector identifying items in the check standard
V_3	I	IRSTOU	vector identifying items to be used as restraint in the next series
V_4	I	INPRNT	print vector
X	I	DESMAT	design matrix
V_5	I	ALCOM	linear combination vector
0	I	OBSERV	observations
Δt	C	TDELT	difference between observed temperature and nominal temperature
C_R	C	CORR	mass correction for restraint in mg.
V_R	C	VOLRES	volume of weights in restraint in cm^3
B	C	TEMP	volume of weights
T_K	C	TKEL	temperature in degrees Kelvin
ρ_a	C	RHOA	air density for average environment conditions
ρ_{ab}	C	RHOAB	air density for "before" environment conditions
ρ_{aa}	C	RHOAA	air density for "after" environment conditions
L	C	ILOAD	vector of loads
L_{max}	C	ALOADP	maximum load
S*	C	STAR	the mass of the sensitivity weight with air buoyancy correction applied
$(\hat{A-B})$	C	D1	predicted difference A-B in scale divisions where A is the unknown weight and B the standard
$\hat{S}$	C	DS1	predicted sensitivity in scale divisions

$\hat{\Delta}$	C	DRIFT	predicted drift in scale divisions
$\hat{LR}$	C	ZERO	predicted left-right effect in scale division
$\overline{D}$	C	DBAR	average of observed sensitivities of load of equal size
S_{mu}	C	SWTPRT	average sensitivity in mass units (mg/ division)
Y	C	A	observed (A-B) in mass units where A is the unknown weight and B the standard
Δ_{mu}	C	DRIFT	drift in mass units
X*	C	XREST	accepted mass correction for retraint in mg.
R_c	C	TMSUM	computed restraint correction in mg. for the m+1 series
Z	C	Y	matrix of normal equations
C	C	Y	diagonal elements of the inverse of the matrix of normal equations
δ	C	DELTA	deviation between observed and predicted weight values
C1	C	CORRP	estimated correction to the nominal in grams
C2	C	OBSCOR	observed correction after iteration
β	C	Y	estimated values of unknown from Z^{-1}
W_R	C	WR	nominal weight of restraint
V	C	COMVOP	computed volume of unknown using estimated corrections
E	C	SERROR	systematic error for each weight
R	C	TRISIG	random error for each weight
U	C	TOTUN	total uncertainty of each weight
V_s	C	SOLSUM	computed value of volume for m+1 series
C_ℓ	C	CORR5A	corrections for linear combination
E_ℓ	C	SER5A	systematic error for linear combination

R_ℓ	C	SIG35A	random error for linear combination
U_ℓ	C	UNC5A	total uncertainty for linear combinations
E_o	C	SERSUM	systematic error for outgoing restraint
R_o	C	T3SIG	random error for outgoing restraint
s	C	OBSTD	observed standard deviation of the series
F	C	FRATIO	f - test ratio
F_t	C	PRETST	critical value for the F distribution
C_c	C	OBCOCK	observed check standard
σ_c	C	OBSCK	standard deviation of observed check standard
T	C	TVAL	t - test value
M_a	C	APPMAS	apparent mass verses brass for final output
M_T	C	TRMASS	mass of weight in grams or pounds for final output
U_f	C	UNCERT	total uncertainty in grams or pounds for final output
V_f	C	VOLPRT	volume at 20°C for final output
C_f	C	COEPRT	coefficient of expansion for final output
CR_f	C	CORRB	apparent mass verses density 8.0 for final output
S_3	C	SUMP	value used to compute volume of restraint for m+1 series

3.0 Information For Users

This section contains information pertinent to the user of the software.

3.1 Description of Input

The input requirements of the computer program are defined in this

section. The data entry column defines each unique data item, not each input record. The data, with a few designated exceptions where a format is given, is recorded in a free field format. The subprogram name and the FORTRAN variable name for each data entry is given along with a brief description of the input parameter. See Appendix A.1 for a listing of sample data.

DATA ENTRY	FORMAT	SUBPROGRAM	VARIABLE NAMES AND DESCRIPTION
#1*	72A1	READ1	B1 - name of company submitting test weight
#2*	72A1	READ1	B2 - address (street name and number)
#3*	72A1	READ1	B3 - address (city, state and zip code)
#4*	72A1	READ1	B4 - description of weights to be calibrated
#5*	72A1	READ1	B5 - serial number of set of weights
#6*	72A1	READ1	B6 - date of report
#7**	72A1	READ1	B7 - test folder number (used for NBS records of calibrations)
#8	Variable	READ1	RANERR, SYSERR, TNOM, IBREST RANERR - 3 standard deviation limit for random error in the starting restraint SYSERR - limit to possible systematic error in the starting restraint TNOM - nominal temperature at which apparent mass and volume are reported in degrees Celsius ***IBREST - starting restraint identification number (2 digits)

* Data entries #1-17 are searched for the first non-blank character at which time all remaining characters are saved for printing on the document, i.e. leading blanks are eliminated.

** On output, only the first 18 non-blank characters are printed.

*** See Figure I.

DATA ENTRY	FORMAT	SUBPROGRAM	VARIABLES NAMES AND DESCRIPTION (continued)
#9*	Variable	READ2	N1, N2, N3, N4 (describe weighing method) N1=0 single transposition N1=1 double transposition N1=2 single transposition N1=3 double substitution N2=0 two pan balance N2=1 one pan balance N3=0 metric units (grams or milligrams) N3=1 English units (pounds) N4=0 regular balance (scale left to right) N4=1 backwards balance (scale right to left)
#10	Variable	READ2	($IDATE_i$, i=1,2,3), IOP, IBAL, ICKUSD $IDATE_1$ - month (2 digits) $IDATE_2$ - day (2 digits) $IDATE_3$ - year (2 digits) } date of measurement IOP - operator number (2 digits) IBAL - balance number (3 digits) ICKUSD - check standard identification (3 digits)
#11	Variable	READ2	T1P, T2P, P1P, P2P, H1P, H2P, CP1, CP2, CT1, CT2, CH1, CH2 T1P, T2P - observed temperature in degrees Celsius before and after measurements are taken P1P, P2P - observed pressure in mm of Mercury before and after measurements are taken H1P, H2P - observed humidity in percent before and after measurements are taken

* Begin reading at this point for each new series.

DATA ENTRY	FORMAT	SUBPROGRAM	VARIABLE NAMES AND DESCRIPTION (Continued)
			CP1, CP2 - pressure corrections in mm of Mercury for observed pressure before and after measurements are taken
			CT1, CP2 - temperature corrections in degrees Celsius for observed temperature before and after measurements are taken
			CH1, CH2 - humidity corrections in percent for observed humidity before and after measurements are taken
#12	Variable	READ2	NOBS, NUNKN, ICALDS, LINVAR
			NOBS - number of observations $\leq$ 50
			NUNKN - number of unknowns $\leq$ 15
			*ICALDS - calibration design number (3 digits)
			LINVAR - number of linear combinations $\leq$ 19
#13	Variable	READ2	STDEBA, SWT, VSWT, CEXSWT, VARBAL
			STDEBA - accepted within standard deviation of the process
			SWT - mass mass value in mg. of the sensitivity weight
			VSWT - volume of sensitivity weight in cm^3 at 20 degrees Celsius
			CEXSWT - coefficient of expansion of sensitivity weight
			VARBAL - accepted between standard deviation of the process in mg.

* See Figure II.

DATA ENTRY	FORMAT	SUBPROGRAM	VARIABLE NAMES AND DESCRIPTION (Continued)
#14*	Variable (Exception- the first 15 characters are for the identification)	READ2	$AIDCST_{j,i}$, j=1,...,5, $ANOM_i$, $DENSTY_i$, $COEFEX_i$, $ACCVAL_i$, i=1,...,NUNKN $AIDCST_{j,i}$, j=1,...,5 - weight identification in positions 1-15 of the input record $ANOM_i$ - nominal weight in grams or pounds $DENSTY_i$ - density of weight in g/cm^3 at 20°C $COEFEX_i$ - coefficient of expansion of weight **$ACCVAL_i$ - accepted correction to weight in mg.
#15	Variable	READ2	$ARSTIN_i$, i=1,...,NUNKN Vector identifying items in the restraint. Entries may be 0 or 1 only.
#16	Variable	READ2	$ACKSTD_i$, i=1,...,NUNKN Vector identifying items in the check, standard. Entries may be 0, -1, or 1.
#17	Variable	READ2	$IRSTOU_i$, i=1,...,NUNKN Vector identifying items in restraint for the m+1 series. This vector has entries of 0 or 1. If there is not another series, entries are all zero.
#18	Variable	READ2	$IPRNT_i$, i=1,...,NUNKN Vector identifying items to be reported in the summary. A value of 1 means report and 0 means omit from report.
#19***	Variable	READ2	****$DESMAT_{j,i}$, j=1,...,NUNKN, i=1,...,NOBS The design matrix consists of entries of 0, 1, or -1 for the series. Each data item contains NUNKN values. Repeat NOBS times.

* Repeat this data entry for each unknown.
** This value is always given in mg., even if the nominal is in pounds.
*** Repeat this data entry for each observation.
**** The design matrix defines the method which is being used to group and intercompare the unknown weights and the check standard (the known weight).

DATA ENTRY | FORMAT | SUBPROGRAM | VARIABLE NAMES AND DESCRIPTION (Continued)

#20 Variable READ2 $ALCOM_{j,i}$, j=1,..., NUNKN; i=1,...,LINVAR. If LINVAR $\neq$ 0

Enter LINVAR vectors containing NUNKN values per vector which describe the required linear combinations. The values in each vector consists 0, 1 or -1.

#21 Variable READ2 $OBSERV_k$ k=1,...,kk where kk $\leq$ 600

Provide readings in scale divisions corresponding to the design and type of weighing as indicated by data entries #9 and #19. The following combinations of N1 and N2 determine the number of entries per record for each observation. If for any reason a reading is not taken, a zero must be used to so indicate.

a. N1=2 and N2=1 Enter $0_1,0_2,0_3$; 2 or 3 values per record

b. N1=2 and N2=0 Enter $0_1,0_2,0_3,0_4,0_5,0_6,0_7,0_8,0_9$; 6 or 9 values per record

c. N1=0 and N2=0 Enter $0_1,0_2,0_3,0_4,0_5,0_6,0_7,0_8,0_9$; 6 or 9 values per record

d. N1=3 and N2=1 Enter $0_1,0_2,0_3,0_4$; 4 values per record

e. N1=3 and N2=0 Enter $0_1,0_2,0_3,0_4,0_5,0_6$; 6 values per record (2 records)

$0_7,0_8,0_9,0_{10},0_{11},0_{12}$

f. N1=1 and N2=0 Enter same as e. above.

Any other combinations of N1 and N2 assumes f. as defined above.

#22 Variable READ2 A value (-20000) terminates the reading of the observations. It is the responsibility of the user to be sure that the number of observations corresponds to the number required by the specified schedule given in data entry #19.

If the vector described in data entry #17 is not equal to zero, continue input of data repeating from data entry #9. If the vector is zero a STOP terminates the input of data. This flag must appear in position 1 through 4 of the input record.

Figure I. Starting Restraint Identification Used at NBS

Given below is an example of frequently used restraint identifications used at NBS. The symbol g denotes grams and kg kilograms.

Restraint Identification	Weights Used in the Restraint
1	N kg_1 + N kg_2
2	NB[1] 100g + AA 100g
4	NB[1] 1g

Figure II. Calibration Design Number Used at NBS

Given below is an example of frequently used calibration identifications with the design, the number of weight and the required number of observations for each.

Design Identification	Design	No. of weights	No. of observations
1	1,1,1	3	3
16	5,2,2,1,1,1	6	8
41	1,1,1,1	4	6
51	1,1,1,1,1	5	10
53	5,3,2,1,1	5	8
62	5,3,2,1,1,1	6	11

3.2 Diagnostic and Error Messages

This section lists all the possible error messages and other informative messages concerning the statistical tests made by the program. The subprogram which contains the message and an explanation of the message is given. The message is given in quotes and an indication (i.e.---) is given if some computed quantity is also printed.

A. "NEG SQRT ARG = ---"

This message is printed by the MAIN program if the value under the radical is negative in the computation of the random error for a weight. If the value under the radical is negative it is assumed to be zero.

B. The following six messages appear in the subprogram ERROR. They are error messages resulting from the execution of subprogram READIT and indicate that an input value is too large or too small for the capacity of the computer being used.

(1) "***** DIAGNOTIC ***** THE NUMBER OF SIGNIFICANT DIGITS IN A NUMBER HAS REACHED ---. THIS MAY PRODUCE OVERFLOW OR UNDERFLOW."

(2) "***** ERROR ***** THE NUMBER OF SIGNIFICANT DIGITS IN A NUMBER HAS REACHED ---. THIS WILL PRODUCE OVERFLOW OR UNDERFLOW."

(3) "***** ERROR ***** NUMBER IS TOO SMALL IN ABSOLUTE VALUE AND WILL PRODUCE UNDERFLOW."

(4) "***** DIAGNOSTIC ***** NUMBER IS SMALL IN ABSOLUTE VALUE AND MAY PRODUCE UNDERFLOW."

(5) "***** DIAGNOSTIC ***** NUMBER IS LARGE IN ABSOLUTE VALUE AND MAY PRODUCE OVERFLOW."

(6) "***** ERROR ***** NUMBER IS TOO LARGE IN ABSOLUTE VALUE AND WILL PRODUCE OVERFLOW."

C. The following error message which occurs in the subprogram ERROR is printed after each of the six messages stated above. It prints out the data item containing the invalid data value.

"THIS OCCURRED IN CONNECTION WITH READING THE DATA ON THE FOLLOWING CARD."

D. The subprogram READIT has an option of specifying an alphanumeric value at the beginning of a data item. If this option does not specify the proper number of characters in the alphanumeric value the following message is printed.

"***** ERROR ***** THE VALUE OF 'KOL' IS --- AND THIS VALUE IS INVALID. KOL MUST BE GREATER THAN 0 AND MUST NOT EXCEED 80."

E. If there are problems in the matrix inversion procedure, one of the following two messages is printed:

(1) "MATRIX IS SINGULAR"

(2) "ERROR IN INVERSE".

If the first message occurs, it indicates that there is some problem with the input data. If the second message is printed it means that the condition

$$\max [I-AA^{-1}] \leq .01\sigma_w$$

was not met. In addition to the message; the original matrix, the inverted matrix and the $[I-AA^{-1}]$ matrix is printed. Both of these messages are printed by the subprogram PRINT2. After the printing of either of the messages the execution of the program is aborted.

F. "STOPPED AT 10 ITERATIONS"

This message is printed by subprogram PRINT2 and indicates that the iterative process used to compute the observed correction (see page 14 of calculations) was terminated at 10 iterations.

G. "INPUT ERROR IN RESTRAINT. CHECK RESTRAINT VECTOR, NOMINAL VALUE, DENSITY AND COEFFICIENT OF EXPANSION OF RESTRAINT --- MG COMPUTED CORRECTION OF RESTRAINT --- MG"

This diagnostic message is printed by subprogram PRINT2 when the following test fails.

$$|[V_1'\tau] \text{ (accepted restraint) } -[V_1' \, C2] \text{ (computed restraint)}| < .1\sigma_W$$

H. One of the following three diagnostic messages concerning the interpretation of the t-test is printed by subprogram PRINT2. See page 17 for calculation of the t-test.

(1) "ABSOLUTE VALUE OF T IS LESS THAN 3. THEREFORE CHECK STANDARD IS IN CONTROL."

$$|T| < 3.0$$

(2) "ALTHOUGH THE ABSOLUTE VALUE OF T IS GREATER THAN OR EQUAL TO 3, THE T VALUE CORRECTED FOR SYSTEMATIC ERROR IS LESS THAN 3, THEREFORE THE CHECK STANDARD IS IN CONTROL."

$$|T| \geq 3 \text{ AND } (T-T_t) < 3.0$$

(3) "ALTHOUGH THE ABSOLUTE VALUE OF T IS GREATER THAN OR EQUAL TO 3, THE DIFFERENCE IS STILL SIGNIFICANT AFTER ALLOWANCE FOR SYSTEMATIC ERROR, THEREFORE THE CHECK STANDARD IS NOT IN CONTROL."

$$|T| \geq 3 \text{ AND } (T-T_t) \geq 3.0$$

I. One of the following two diagnostic messages concerning the interpretation of the F-test is printed by subprogram PRINT2. The critical value is printed in the space denoted by --. See page 16 for the calculations of the F ratio.

(1) "F RATIO IS LESS THAN---(CRITICAL VALUE FOR PROBABILITY = .01). THEREFORE THE STANDARD DEVIATION IS IN CONTROL."

$$F \leq F_t$$

(2) "F RATIO IS GREATER THAN---(CRITICAL VALUE FOR PROBABILITY = .01). THEREFORE THE STANDARD DEVIATION IS NOT IN CONTROL."

$$F > F_t$$

3.3 Description of Data Output Used for Process Control

If neither the t-test or F-test fails, selected values are saved on a unformatted temporary file during the execution of the program. The temporary file is defined by the variable ITMP in the BLKDAT subprogram. See section 4.6. The subprogram FINPRT reads the temporary file, ITMP, and generates a formatted file (IP as defined by subprogram BLKDAT) of the saved parameters.

The table below defines the parameters with their corresponding format. All parameters are contained in an 80 character record. Appendix A.3 lists the process parameters saved from the sample run given in Appendix A.2.

Variable	Description	Format
$IDATE_1$ $IDATE_2$, $IDATE_3$	date	3I2
IBREST	restraint identification	I2
ICKUSD	check standard identification	I3
OBCOCK	observed check standard value	F11.5
IBAL	balance identification	I3
OBSTD	observed standard deviation	F9.5
NDGFR	degrees of freedom	I2
ICALDS	calibration identification	I3
TBAR	average corrected temperature	F5.2
DIFT	difference between "before" and "after" temperature reading	F5.2
PBAR	average corrected pressure	F6.2
DIFP	difference between "before" and "after" pressure reading	F5.2
HBAR	average corrected humidity	F7.4
DIFH	difference between "before" and "after" humidity reading	F4.1
RHOA	air density as a function of TBAR, PBAR and HBAR	F6.4
IOP	operator	I2
	denotes standard	1HS

4.0 Implementation Information

This section describes the information needed for implementing the FORTRAN computer software. Information is given concerning the flow and function of the MAIN program and all subprograms. In addition, a cross reference table of labeled COMMON; the use of the DATA, DOUBLE-PRECISION

and EQUIVALENCE statements; the function of switch variables in the various subprogram and other information which may be bothersome on implementation are given. Figure III on page 43 gives a flow chart of the program. Figure IV on page 44 gives a cross reference table of labeled COMMON.

4.1 Description of MAIN program and all Subprograms

The software consists of one main program and 23 subprograms. This section describes briefly the function of each. The subprogram descriptions are listed in the order in which they are called during the execution of the program.

4.1.01 MAIN Program

This program controls the flow of the input, calculations and output. All the calculations described in Section 2.0 are performed in this program with the exception of a few computations which are performed in subprograms PRINT2 and READ2.

4.1.02 BLKDAT Subprogram

This subprogram is a BLOCK DATA subprogram and contains values which may need to be changed to comply with the demands of a specific computer or computer operating system. The DATA statements define the following values:

a. Machine zero 1×10^{-8} (UNIVAC 1108)

b. Characters: 0-9, blank, - , . , * , + , comma, D and E

c. Input unit number, output unit numbers and number of lines per page

d. Flag STOP to detect end of data and blank

e. The number 10 which controls the number of iterations in the MAIN program. See page 13.

4.1.03 READ1 Subprogram

This subprogram reads data that is common to all series. Eight data entries are read consisting of administrative data, statistical control parameters, nominal temperature and the starting restraint identification. The first seven data entries consisting of administrative information, company name and address and description of weights being tested, are read with a 72A1 format specification. The information may occur anywhere within the 72 position limit. Leading blanks are eliminated before the information is printed on the report. The eighth data entry gives the values for random error, systematic error, nominal temperature and the starting restraint identification. The values are read by a subprogram, READIT, which permits input in a variable format. Four values are assumed to be given and no check is made for missing values.

4.1.04 READIT Subprogram

This subprogram provides for input in variable format and is used by subprograms READ1 and READ2. The input data is restricted to first 80 positions of the input record. Alphanumeric data may be given in the first n, where n is specified, positions. These characters are saved for output. Numberic values are separated by one or more blanks, a comma, any letter except D or E, or any other permitted character except a plus sign (+), a minus sign (-) or a decimal (.). Numeric values may appear in integer form or floating point form using a decimal point or an exponent in which case the letter D or E must precede the exponent. Values with a D preceding the exponent are accepted only as single precision values, not as double precision values.

4.1.05 ERROR Subprogram

This subprogram is used in conjunction with subprogram READIT described in section 4.1.04. It contains the output statements and corresponding formats for the printing of errors associated with the subprogram READIT's interpretation of meaningless input data.

4.1.06 PRINT1 Subprogram

This subprogram prints the title page and pages 1, 2, 3, 4, 5 and 6 of the report generated for each calibration. This information is pertinent only to the NBS calibration program.

4.1.07 TEXT1 Subprogram

This subprogram contains the output statements and their corresponding formats for the printing of page 1 of the calibration report.

4.1.08 TEXT2 Subprogram

This subprogram contains the output statements and their corresponding format for the printing of page 2 of the calibration report.

4.1.09 TEXT3 Subprogram

This subprogram contains the output statements and their corresponding formats for the printing of page 3 of the calibration report.

4.1.10 TEXT4 Subprogram

This subprogram contains the output statement and their corresponding formats for the printing of page 4 of the calibration report.

4.1.11 TEXT5 Subprogram

This subprogram contains the output statements and their corresponding formats for the printing of page 5 of the calibration report.

4.1.12 TEXT6 Subprogram

This subprogram contains the output statements and their corresponding formats for the printing of page 6 of the calibration report.

4.1.13 READ2 Subprogram

This subprogram uses the subprogram READIT, described in section 4.1.04, to read the following information which is needed for each series.

a. Description of the weighing method

b. Administrative data--date, operator, balance identification and check standard identification

c. Environmental conditions--temperature, pressure, humidity

d. Number of observations, number of unknowns, design identification and number of linear combinations

e. Standard deviation of balance, mass of sensitivity weight, volume of sensitivity weight, coefficient of expansion of sensitivity weight, accepted between standard deviation of the process

f. Information about test item: weight, density, coefficient of expansion and accepted correction

g. Restraint vector

h. Check standard vector

i. Restraint vector for next series

j. Report vector

k. Design matrix

l. Linear combination vector(s)

m. Observations--Reading of observations is terminated by a -20000 entry.

Information given in pounds is converted to grams. A control parameter designated by the weighing method parameter is defined. The average values for the corrected temperature, pressure and humidity are computed.

4.1.14 SPINV Subprogram

This subprogram inverts the augmented matrix of normal equations. A check is made for singularity. A call is made to subprogram INVCHK for the purpose of checking the success or failure of the inversion.

4.1.15 SAVMTX Subprogram

This subprogram is used by subprogram SPINV described in 4.1.14. The original matrix is saved before the inverse operation of subprogram SPINV begins.

4.1.16 INVCHK Subprogram

This subprogram called by subprogram SPINV makes a check on the success of the matrix inversion. The check $[I-AA^{-1}] < E$ is made where I is the identity matrix, A is the original matrix, A^{-1} is the inverse of A and E is the value $.01\sigma_w$ where σ_w is the accepted standard deviation of the balance. If the conditions are not met, a flag is defined.

4.1.17 PRINT2 Subprogram

This subprogram makes necessary calculations and contains output statements and their corresponding formats for the printing of the four or five pages of the report associated with each series. The first page of the output contains administrative information: statistical control

values, restraint information, check standard information, test environmental conditions and description of weights being calibrated. The second page of the output contains the design and the observations. The third page of the output contains the computed values for the corrections and their corresponding uncertainties and pertinent information of the restraint for the next series. The fourth or fifth page of the output contains the information concerning the statistical F-test and t-test. If neither the t-test or F-test fails, values are saved for process control . See section 3.3. The fourth page, if linear combinations are requested, contains information related to the requested linear combinations.

4.1.18 CHKLN Subprogram

This subprogram makes a check between the current number of lines on a page of printout and the parameter controlling the number of lines permitted per page. If the maximum is exceeded subprogram PGCONT is called.

4.1.19 PGCONT Subprogram

This subprogram writes the information needed in the case where a continuation page is required due to output page overflow.

4.1.20 HEADPG Subprogram

This subprogram writes the headings on each page. The heading includes the company name and address, a description of the weights being tested, the balance, the date, the page number and the series number.

4.1.21 FINPRT Subprogram

This subprogram controls the printing of the four summary pages for each calibration report. If mass was given in English units, the values are converted to grams for the output. The reported corrections are printed in milligrams. The subprogram TEXTS1 and TEXTS2 are called to print the summary text. A subprogram called DPFD is used to print double precision values of mass and corrections in fixed notations (see Table I and Table II of the output example).

4.1.22 TEXTS1 Subprogram

This subprogram contains the output statements and their corresponding formats for printing the text of the first page of the summary.

4.1.23 TEXTS2 Subprogram

This subprogram contains the output statements and their corresponding formats for printing the text of the second page of the summary.

4.1.24 DPFD Subprogram

This subprogram converts a double precision value to a string of numeric characters representing its values to be printed as a fixed floating point data type with more than 8 accurate digits, the number permitted on the UNIVAC 1108.

4.2 Labeled COMMON

Figure IV lists all the labeled COMMON areas and the main program and all its subprograms. Check marks indicate which subprograms use which labeled COMMON areas. The numbers in parentheses indicate the amount of storage required.

4.3 Double Precision Variables

The following table defines the subprograms using double precision variables, the variable names and in which labeled COMMON area they appear. N.A. means not applicable.

Variable	Subprogram	COMMON
VOLP	MAIN	N.A.
CORRP	MAIN	N.A.
OBSCOR	MAIN, PRINT2	COMPUT
TRMASS	MAIN, FINPRT	REPRT
APPMAP	MAIN	N.A.
APPMAS	MAIN, FINPRT	REPRT
CORRBB	MAIN	N.A.
CORRB	MAIN, FINPRT	REPRT
SUM	MAIN	N.A.
SUM1	MAIN	N.A.
TEMPAR	FINPRT	N.A.
A	DPFD	N.A.
X	DPFD	N.A.

FIGURE III. FLOW CHART OF PROGRAM

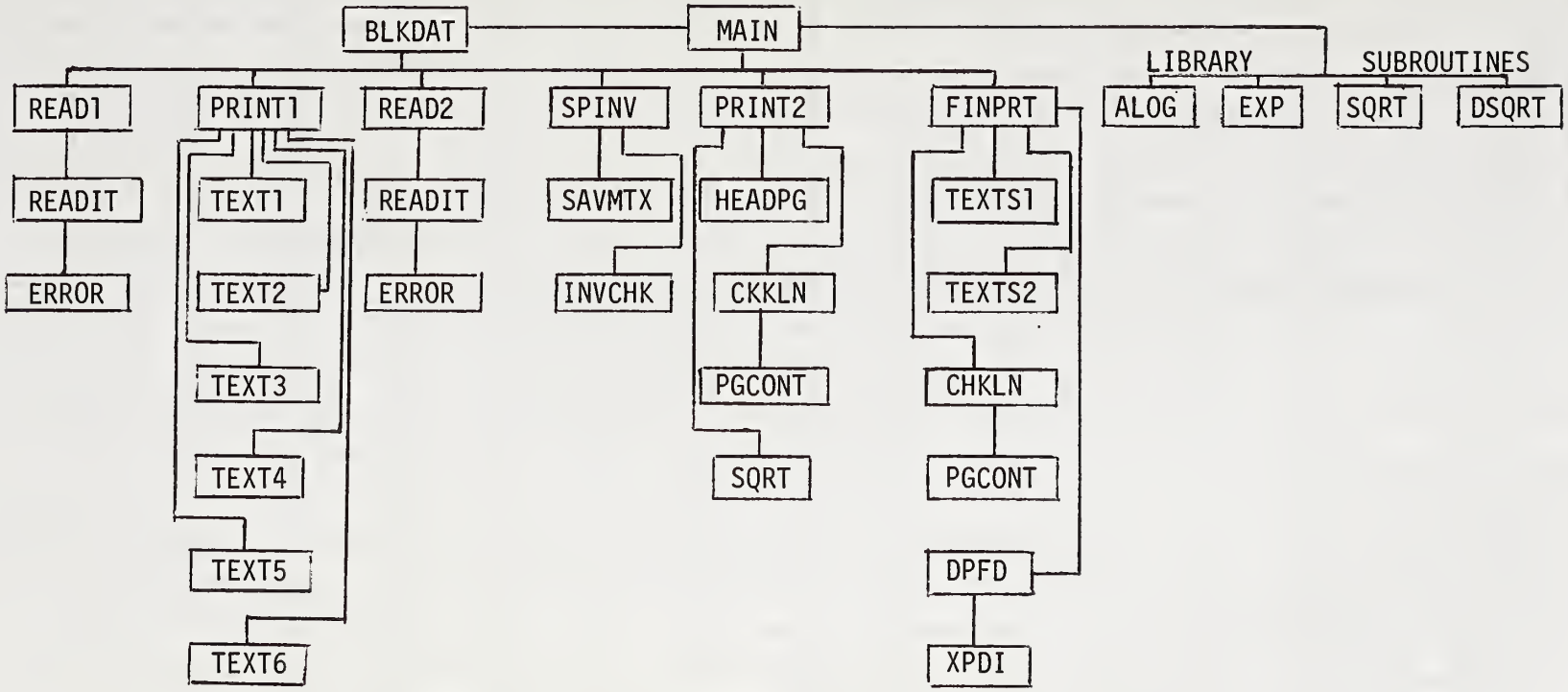

FIGURE IV - LABELED COMMON CROSS REFERENCE TABLE

	BLKDAT	CHKLN	DPFD	FINPRT	HEADPG	INVCHK	MAIN	PGCONT	PRINT1	PRINT2	READ1	READ2	READIT	SAVMTX	SPINV	TEXT1	TEXT2	TEXT3	TEXT4	TEXT5	TEXT6	TEXTS1	TEXTS2
CHECK (1544)						X	X			X				X									
COMPUT (1057)							X			X													
DPFDVL (22)	X		X				X			X			X										
INPUT (3531)				X	X		X	X		X		X											
INVCST (1)	X														X								
ITSTOP (1)	X						X																
PCHOUT (1)				X						X													
PRT1 (1005)				X	X		X	X	X	X	X	X											
PRT2 (3)		X		X	X		X	X	X	X													
PRTLB (17)										X		X											
RAREA (115)											X	X											
REPRT (1275)				X			X																
STOP (5)	X										X												
UNITIO (5)	X	X		X	X		X	X	X	X	X		X			X	X	X	X	X	X	X	X

4.4 Equivalenced Variables

The FORTRAN EQUIVALENCE statement is used only in subprogram READIT. Following is a table giving the two variables which are equivalenced.

Variable 1	Variable 2	Constant Value
IDIGIT (1)	KFD (1)	0
IDIGIT (2)	KFD (2)	1
IDIGIT (3)	KFD (3)	2
IDIGIT (4)	KFD (4)	3
IDIGIT (5)	KFD (5)	4
IDIGIT (6)	KFD (6)	5
IDIGIT (7)	KFD (7)	6
IDIGIT (8)	KFD (8)	7
IDIGIT (9)	KFD (9)	8
IDIGIT (10)	KFD (10)	9
IPLUS	KFD (15)	+
IMINUS	KFD (12)	-
ID	KFD (17)	D
IE	KFD (18)	E
IDECML	KFD (13)	.
IBLANK	KFD (11)	blank

4.5 Parameter Dependent Variables The following table gives a list of dimensioned variables whose size may be changed due to modification in the number of observations, number of unknowns or number of linear combinations. The first column gives the variable name and its current dimension, where n (the number of observations) = 50, k (the number of unknowns) = 15, ℓ (the number of linear combinations) = 19, and

m (number of values saved to be printed on summary page) = 50. The second column gives the COMMON area containing the variable. The N.A. entry means that the variable is not in a labeled COMMON area. The third column lists the names of the subprogram(s) containing the variable.

Variable	Labeled COMMON	Subprograms
AIDCST (5,k)	INPUT	MAIN, READ2, PRINT2, PGCONT, HEADPG, FINPRT
ANOM (k)	INPUT	MAIN, READ2, PRINT2, PGCONT, HEADPG, FINPRT
DENSTY (k)	INPUT	MAIN, READ2, PRINT2, PGCONT, HEADPG, FINPRT
COEFEX (k)	INPUT	MAIN, READ2, PRINT2, PGCONT, HEADPG, FINPRT
ACCVAL (k)	INPUT	MAIN, READ2, PRINT2, PGCONT, HEADPG, FINPRT
ARSTIN (k)	INPUT	MAIN, READ2, PRINT2, PGCONT, HEADPG, FINPRT
ACKSTD (k)	INPUT	MAIN, READ2, PRINT2, PGCONT, HEADPG, FINPRT
IRSTOU (k)	INPUT	MAIN, READ2, PRINT2, PGCONT, HEADPG, FINPRT
IPRNT (k)	INPUT	MAIN, READ2, PRINT2, PGCONT, HEADPG, FINPRT
DESMAT (k,n)	INPUT	MAIN, READ2, PRINT2, PGCONT, HEADPG, FINPRT
OBSERV (12*n)	INPUT	MAIN, READ2, PRINT2, PGCONT, HEADPG, FINPRT
ALCOM (k,ℓ+1)	INPUT	MAIN, READ2, PRINT2, PGCONT, HEADPG, FINPRT
SWTPRT (n)	COMPUT	MAIN, PRINT2
A (n)	COMPUT	MAIN, PRINT2
DELTA (n)	COMPUT	MAIN, PRINT2
OBSCOR (k)	COMPUT	MAIN, PRINT2
COMVOL (k)	COMPUT	MAIN, PRINT2
SERROR (k)	COMPUT	MAIN, PRINT2
TRISIG (k)	COMPUT	MAIN, PRINT2
TOTUN (k)	COMPUT	MAIN, PRINT2
DRIFT (n)	COMPUT	MAIN, PRINT2

Variable	Labeled COMMON	Subprograms
ZERO (n)	COMPUT	MAIN, PRINT2
COMVOP (k)	COMPUT	MAIN, PRINT2
CORR5A (ℓ+1)	COMPUT	MAIN, PRINT2
SIG35A (ℓ+1)	COMPUT	MAIN, PRINT2
UNC5A (ℓ+1)	COMPUT	MAIN, PRINT2
IOTSTR (n)	COMPUT	MAIN, PRINT2
SER5A (ℓ+1)	COMPUT	MAIN, PRINT2
DS1 (n)	COMPUT	MAIN, PRINT2
VOLP (k)	N.A.	MAIN
CORRP (k)	N.A.	MAIN
TEMP (k)	N.A.	MAIN
D1 (n)	N.A.	MAIN
ILOAD (n)	N.A.	MAIN
TEMP2 (k)	N.A.	MAIN
ALOAD (n)	N.A.	MAIN
AITEM (5,m)	REPRT	MAIN, FINPRT
APPMAS (m)	REPRT	MAIN, FINPRT
TRMASS (m)	REPRT	MAIN, FINPRT
UNCERT (m)	REPRT	MAIN, FINPRT
VOLPRT (m)	REPRT	MAIN, FINPRT
CORRB (m)	REPRT	MAIN, FINPRT
COEPRT (m)	REPRT	MAIN, FINPRT
BCHK ($2(k+2)^2$)	CHECK	MAIN, SAVMTX, INVCHK, PRINT2
Y ($(k+2)^2$)	CHECK	MAIN, SAVMTX, INVCHK, PRINT2
PRTLBX (k)	PRTLB	MAIN, READ2, PRINT2

Variable	Labeled COMMON	Subprograms
ITEMP (k)	N.A.	PRINT2
KTEMP (k)	N.A.	PRINT2
JTEMP (k)	N.A.	PRINT2
NNP (m)	N.A.	FINPRT
TEMPAR (m)	N.A.	FINPRT
TRMASX (k)	N.A.	FINPRT

In addition to the above dimensioned variables which could be changed, a variable defined as NR = n*12 in subprogram READ2 would have to be changed if the number of observations is increased from the current assigned value of 50.

4.6 Hardware and System Dependent Variables

The following table describes the variables which may present some problem at implementation time. The table lists the variables, the subprograms defining them and the value used for the UNIVAC 1108 at NBS.

Variable Name	Defining Subprogram	Current Value and Description of Variable
ZERMAC	BLKDAT	1×10^{-8} - machine zero
IR	BLKDAT	5 - input unit
IW	BLKDAT	6 - output (printer) unit
IP	BLKDAT	1 - output (punch) unit
IPL	BLKDAT	58 - maximum number of lines allowed per printed page
ITMP	BLKDAT	7 output (temporary file)
T	READIT	This dimensioned variable contains the limits of a real variable beginning at 10^{-38} and going up to 10^{38}

Variable Name	Defining Subprogram	Current Value and Description of Variable
IZERO	READIT	39-number of unique powers of ten represented by the machine range of a real variable given in T above
MAX	READIT	77-number of powers of ten represented by the machine range of a real variable as specified above in T
KFD	BLKDAT	Define in hollerith notation the characters 0-9, blank, -, ., *, +, comma, D and E which are used by the subprogram READIT and DPFD
FS	BLKDAT	hollerith character S
FT	BLKDAT	hollerith character T
FO	BLKDAT	hollerith character 0
FP	BLKDAT	hollerith character P
FB	BLKDAT	hollerith character Δ (blank)

**

4.7 Required Storage

The following table lists all subprograms and labeled common blocks. For the subprogram, the number of lines of FORTRAN statements and the number of memory locations for the code and data are given. If the entry is a labeled COMMON area, a C preceeds the entry and the memory locations needed are given under the column headed DATA.

**FS, FT, FO and FP are used by subprogram READ1 to check for the end of a set of data.

	PROGRAM OR COMMON	LINES OF CODE	MEMORY FOR CODE	MEMORY FOR DATA
	BLKDAT	41		
C	CHECK			868
	CHKLN	11	21	5
C	COMPUT			559
	DPFD	89	194	40
C	DPFDVL			18
	ERROR	56	160	168
	FINPRT	181	486	363
	HEADPG	36	41	26
C	INPUT			1881
C	INVCST			1
	INVCHK	69	140	36
C	ITSTOP			1
	MAIN	628	1426	352
C	PCHOUT			1
	PGCONT	53	68	32
	PRINT1	67	192	116
	PRINT2	670	1785	1212
C	PRT1			517
C	PRT2			3
C	PRTLB			15
C	RAREA			77
	READ1	120	170	23
	READ2	325	516	34
	READIT	356	586	209
C	REPRT			701
	SAVMTX	22	22	9
	SPINV	126	293	43
C	STOP			5
	TEXT1	125	64	705
	TEXT2	125	64	705
	TEXT3	125	64	705
	TEXT4	125	64	705
	TEXT5	121	64	683
	TEXT6	40	24	172
	TEXTS1	124	59	704
	TEXTS2	30	19	95
C	UNITIO			5
	TOTAL (excluding text)	2850	6100	7320
	TOTAL (text)	815	422	4474
	GRAND TOTAL	3665	6522	11794

Acknowledgements

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REFERENCES

The following references are suggested for detailed description of portions of this report, and for general information concerning the mass measurement process:

1. Pontius, P. E., and Cameron, J. M., "Realistic Uncertainties and the Mass Measurement Process," NBS, (U.S.), Monogr. 103, Aug. 15, 1967.

2. Pontius, P. E., "Measurement Philosophy of the Pilot Program for Mass Calibration," NBS (U.S.), Tech. Note 288, May 6, 1966.

3. Bowman, H. A., and Schoonover, R. M. with Appendix by Mildred Jones, "Procedure for High Precision Density Determinations by Hydrostatic Weighing," J. Res. NBS (U.S.), 71C. Engineering and Instrumentation No. 3, 179-198, July-Aug. 1967.

4. Natrella, M. B., "Experimental Statistics," NBS (U.S.), Handbook 91, Aug. 1, 1963.

5. Ku, H. H., "Precision Measurement and Calibration," Selected NBS papers on Statistical Concepts and Procedures, NBS (U.S.), Spec. Pub. 300, Vol. 1, Feb. 1969.

6. Pontius, P. E., "Mass and Mass Values," NBS (U.S.), Monogr. 133, Jan. 1974.

7. Cameron, J. M., "The Use of the Method of Least Squares in Calibration," NBS (U.S.) NBSIR 74-587, Sept. 1974.

8. Almer, H. W. and Keller, Jerry, "Surveillance Test Procedures, NBS (U.S.) NBSIR 76-999, Feb. 1976.

9. Wexler, A. and Greenspan, L. "Vapor Pressure Equation for Water in the Range 0°C to 100°C," NBS Journal of Research for Physics and Chemistry, Vol. 75A, No. 3, May-June 1971.

10. Cameron, J. M., Croarkin, M. C. and Raybold, R.C., "Designs for Calibration of Standards of Mass," NBS, (U.S.), Tech. Note 952, June 1977.

11. Cameron, J. M. and Hailes, G. E., "Designs for the Calibration of Small Groups of Standards in the Presence of Drift," NBS (U.S.), Tech. Note 844, Aug. 1974.

12. Pearson, E. S. and Hartley, H. O., Biometrika Tables for Statisticians, Vol. 1, Cambridge Press, 1956, page 131.

APPENDIX A.1--SAMPLE INPUT

```
X Y Z CORPORATION
SOMEWHERE, U.S.A.
SET OF MASS STANDARDS : 5KG - 100MG
SERIAL NUMBER 12345
MANUFACTURER : TROEMNER, INC.
JUNE 21, 1979
654321
0 .076 20 80
0 0 0 0
5 24 79 84 001 002
21.98 22.22 733.68 734.08 41 41
8 5 53 0
1.15 49.98277 .00301104 .000020 0
        5KG        5000 7.953 .000045
        3KG        3000 7.953 .000045
        2KG        2000 7.9 .000045
      S 1KG-1        1000 8.0064 .000045 11.241
      S 1KG-2        1000 8.0063 .000045 11.825
0 0 0 1 1
0 0 0 1 -1
0 0 0 1 1
1 1 1
1 -1 -1 1 -1
-1 1 1 1 -1
1 -1 -1
-1 1 0 1 1
0 -1 1 1
0 1 -1 0 -1
0 0 1 -1 -1
0 0 0 1 -1
4.7 15.2 5.0 5.4 12.5 5.5 7.3 15.0 7.4
5.8 12.4 6.2 5.6 14.1 5.9 7.8 16.4 8.2
6.4 13.6 6.5 4.4 13.4 4.5 7.2 15.2 7.3
4.8 13.4 5.0 5.4 15.2 5.7 7.3 17.4 7.6
6.0 14.8 6.3 5.3 13.0 5.4 6.7 16.0 7.0
5.2 13.0 5.3 5.4 16.0 5.6 9.2 16.5 9.3
5.9 14.0 6.2 5.9 13.4 6.2 7.8 16.2 8.0
5.9 13.9 6.1 5.0 14.8 5.2 8.6 15.8 8.6
-200000
3 1 0 0
5 23 79 84 003 002
21.91 21.92 736.86 736.76 40 40
6 4 41 0
.028 49.98277 .00301104 .000020 0
      S 1KG-1        1000 8.0064 .000045 11.241
      S 1KG-2        1000 8.0063 .000045 11.825
        1KG        1000 7.953 .000045
    SUM 1KG        1000 7.92641 .000045
1 1
1 -1
0 0 0 1
```

```
0 0 1
0 1
1 0 -1
1 0 0 -1
0 1 -1
0 1 0 -1
0 0 1 -1
16.74 17.34 67.37 66.73
16.85 11.24 61.18 66.77
16.84 13.17 63.11 66.76
17.32 11.13 61.06 67.23
17.22 13.02 62.93 67.16
10.92 12.82 62.86 60.84
-200000
3 1 0 0
5 23 79 84 003 004
21.92 21.96 736.92 736.58 40 40
11 6 62 1
.028 49.98277 .00301104 .000020 0
     500G          500 7.9 .000045
     300G          300 7.953 .000045
     200G          200 7.953 .000045
     100G          100 7.9 .000045
   S    100G           100 7.953 .000045 .9883
 SUM 100G          100 7.94234 .000045
1 1 1
0 0 0 0 1
0 0 0 0 0 1
1 1 1 1
1 -1 -1 1 -1
1 -1 -1 0 1 -1
1 -1 -1 -1 0 1
1 -1 -1
1 0 -1 -1 -1 -1
0 1 -1 1 -1 -1
0 1 -1 -1 1 -1
0 1 -1 -1 -1 1
0 0 1 -1 -1
0 0 1 -1 0 -1
0 0 1 0 -1 -1
1 0 0 1
12.78 10.62 60.63 62.86
13.02 12.59 62.54 62.96
14.86 10.75 60.73 64.88
12.86 10.61 60.54 62.82
12.91 13.58 63.54 62.81
10.87 13.44 63.33 60.84
10.94 13.33 63.26 60.82
12.69 11.44 61.38 62.66
11.18 11.71 61.68 61.14
11.18 13.50 63.38 61.11
11.09 13.44 63.40 60.96
-200000
3 1 0 0
5 17 79 84 005 006
21.99 21.96 746.60 746.00 31 31
11 6 62 0
.012 49.98277 .00301104 .000020 0
```

```
      50G          50 7.953 .000045
      30G          30 7.953 .000045
      20G          20 7.9 .C00045
      10G          10 7.953 .000045
    S 10G          10 7.953 .000045 .0785
  SUM 10G          10 7.92641 .000045
1 1 1
0 0 0 0 1
0 0 0 0 0 1
1 1 1 1
1 -1 -1 1 -1
1 -1 -1 0 1 -1
1 -1 -1 -1 0 1
1 -1 -1
1 0 -1 -1 -1 -1
0 1 -1 1 -1 -1
0 1 -1 -1 1 -1
0 1 -1 -1 -1 1
0 0 1 -1 -1
0 0 1 -1 0 -1
0 0 1 0 -1 -1
6.18 4.69 54.71 56.20
6.17 4.72 54.71 56.15
6.14 4.76 54.76 56.14
6.19 4.74 54.72 56.18
6.18 4.47 54.45 56.18
4.81 4.44 54.44 54.81
4.79 4.49 54.47 54.75
4.76 4.51 54.49 54.74
4.52 4.55 54.52 54.49
4.48 4.52 54.50 54.47
4.47 4.47 54.46 54.47
-200000
3 1 0 0
5 18 79 84 007 008
21.92 21.88 743.28 742.82 35 35
11 6 62 1
.0017 5.00171 .00185248 .000069 0
       5G          5 7.9 .000045
       3G          3 7.953 .000045
       2G          2 7.953 .000045
       1G          1 7.9 .C00045
     S 1G          1 7.953 .000045 -.0792
   SUM 1G          1 16.6 .C00020
1 1 1
0 0 0 0 1
0 0 0 0 0 1
1 1 1 1
1 -1 -1 1 -1
1 -1 -1 0 1 -1
1 -1 -1 -1 0 1
1 -1 -1
1 0 -1 -1 -1 -1
0 1 -1 1 -1 -1
0 1 -1 -1 1 -1
0 1 -1 -1 -1 1
0 0 1 -1 -1
0 0 1 -1 0 -1
```

```
0 0 1 0 -1 -1
1 0 0 1
1.084 .926 5.927 6.084
.978 .939 5.931 5.972
.990 1.021 6.021 5.987
1.068 1.013 6.009 6.067
1.068 .875 5.870 6.063
1.062 .862 5.857 6.053
.959 .966 5.957 5.948
.969 .948 5.942 5.960
1.016 .976 5.966 6.006
1.016 .987 5.981 6.006
1.012 .881 5.872 6.004
-200000
3 1 0 0
5 18 79 84 007 008
22.21 22.99 742.52 741.86 36 35
11 6 62 0
.0005 .50156 .001857 .000069 0
     500MG        .5 16.6 .000020
     300MG        .3 16.6 .000020
     200MG        .2 16.6 .000020
     100MG        .1 16.6 .000020
   S 100MG        .1 16.6 .000020 -.02628
 SUM 100MG        .1 5.17583 .000049
1 1 1
0 0 0 0 1
0
1 1 1 1
1 -1 -1 1 -1
1 -1 -1 0 1 -1
1 -1 -1 -1 0 1
1 -1 -1
1 0 -1 -1 -1 -1
0 1 -1 1 -1 -1
0 1 -1 -1 1 -1
0 1 -1 -1 -1 1
0 0 1 -1 -1
0 0 1 -1 0 -1
0 0 1 0 -1 -1
296.4 224.0 726.2 801.2
285.5 240.3 741.3 788.9
300.5 241.6 744.1 803.7
312.9 253.5 754.8 815.5
312.7 239.8 741.0 815.6
303.8 250.5 751.5 805.7
290.2 264.6 765.4 791.7
303.6 252.3 753.6 806.0
276.7 302.6 804.1 779.3
276.7 315.5 817.1 779.2
276.6 301.0 802.6 778.6
-200000
STOP
```

APPENDIX A.2--SAMPLE PRINTED OUTPUT

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
NATIONAL ENGINEERING LABORATORY
WASHINGTON, D.C. 20234

R E P O R T
O F
M A S S V A L U E S

X Y Z CORPORATION
SOMEWHERE, U.S.A.
SET OF MASS STANDARDS : 5KG - 100MG
SERIAL NUMBER 12345
MANUFACTURER : TROEMNER, INC.
JUNE 21, 1979

TEST NUMBER 654321

FOR THE DIRECTOR,

G. E. MATTINGLY, CHIEF
FLUID ENGINEERING DIVISION
CENTER FOR MECHANICAL ENGINEERING
AND PROCESS TECHNOLOGY
NATIONAL ENGINEERING LABORATORY

INTRODUCTION

THIS DOCUMENT IS A COMPREHENSIVE REPORT COVERING THE SEQUENCE OF OPERATIONS USED TO ASSIGN MASS VALUES TO THE WEIGHTS IDENTIFIED ABOVE. IT INCLUDES A COMPLETE DESCRIPTION OF THE MEASUREMENT METHODS AND PROCEDURES WHICH WERE USED, ALL OF THE DATA, AND THE ANALYSIS OF THIS DATA. THE RESULTS ARE PRESENTED IN SEVERAL FORMATS. ASSIGNED MASS VALUES, DISPLACEMENT VOLUMES, COEFFICIENTS OF EXPANSION, UNCERTAINTIES, TOGETHER WITH THE SUMMED VALUES FOR LINEAR COMBINATIONS OF THE WEIGHTS IN EACH DECADE ARE PRESENTED AT THE END OF THE APPROPRIATE SERIES. THIS INFORMATION SHOULD BE USEFUL TO THOSE WHO MUST ASSIGN MASS VALUES TO OBJECTS OTHER THAN WEIGHTS. FOR CONVENIENCE, THE VALUES AND UNCERTAINTIES, TOGETHER WITH OTHER APPROPRIATE DATA AND COMMENTS ARE ALSO SUMMARIZED IN TABLES I AND II AT THE END OF THE REPORT. CERTAIN INTERMEDIATE PAGES ARE SUMMARIES OF STATISTICAL DATA WHICH RELATE TO THE MASS MEASUREMENT PROCESS USED TO PERFORM THIS WORK. THESE PAGES HAVE BEEN LEFT IN THE REPORT TO RETAIN CONTINUITY. COPIES OF THESE PAGES BECOME PART OF A COLLECTION OF STATISTICAL DATA WHICH REFLECTS THE MEASUREMENT PROCESS PERFORMANCE OVER A PERIOD OF TIME. SUCH A COLLECTION HAS BEEN USED TO ESTABLISH THE CONTROL LIMITS FOR ACCEPTING THE RESULTS OF THIS MEASUREMENT. THESE COLLECTIONS ARE OPEN FOR INSPECTION AT OUR FACILITY.

THE MASS MEASUREMENT SYSTEM

THE MASS MEASUREMENT SYSTEM WITHIN THIS COUNTRY CONSISTS OF ALL OF THE MEASUREMENT PROCESSES WHICH RELY, DIRECTLY OR INDIRECTLY, ON MASS MEASUREMENTS TO ACCOMPLISH A WIDE VARIETY OF ENDEAVORS. IN ORDER FOR THIS SYSTEM TO FUNCTION PROPERLY, EVERYONE WHO MAKES MEASUREMENTS MUST BE ABLE TO VERIFY THAT HIS MEASUREMENT PROCESS PRODUCES CONSISTENT RESULTS WHICH ARE COMPATIBLE WITH HIS PARTICULAR REQUIREMENTS. THE WEIGHTS COVERED BY THIS REPORT, TOGETHER WITH THE ASSIGNED VALUES AND THE APPROPRIATE UNCERTAINTIES FOR THESE VALUES, PROVIDE IN PART A BASIS FOR CONSISTENT MEASUREMENTS WITHIN THIS SYSTEM OF RELATED MEASUREMENT PROCESSES.

APPROPRIATE CHARACTERIZATION OF ANY MEASUREMENT PROCESS IS FUNDAMENTAL TO VERIFYING THAT RESULTS ARE CONSISTENT WITH THE END REQUIREMENT WITH RESPECT TO CORRECTNESS AND ECONOMY OF THE MEASUREMENT EFFORT. WITHOUT THIS INFORMATION, THE BENEFITS OF OWNERSHIP OF THESE WEIGHTS MAY BE COMPLETELY ILLUSORY. THE ASSIGNED UNCERTAINTIES IN THIS REPORT ARE DESCRIPTIVE OF OUR MASS MEASUREMENT PROCESS. EFFECTIVENESS OF THE TRANSFER OF THE UNIT FROM ONE FACILITY TO ANOTHER SHOULD BE VERIFIED BY AN INDEPENDENT TEST. IT IS PRESUMED THAT THESE WEIGHTS WILL BE USED IN A SIMILARLY WELL-CHARACTERIZED MEASUREMENT PROCESS SO THAT THE STATISTICAL PARAMETERS OF BOTH PROCESSES CAN BE COMBINED TO PROVIDE A REALISTIC ESTIMATE OF THE UNCERTAINTY OF THE MASS UNIT AS ACTUALLY REALIZED IN ANOTHER FACILITY. A COMPREHENSIVE SERVICE DIRECTED TOWARD THE EVALUATION OF A PARTICULAR MASS MEASUREMENT PROCESS IS AVAILABLE THROUGH THE MASS MEASUREMENT ASSURANCE PROGRAM OF THE NATIONAL BUREAU OF STANDARDS.

WEIGHING DESIGN

ONLY DIFFERENCES IN MASS CAN BE MEASURED, THEREFORE THE MASS VALUES FOR THE 'UNKNOWN' WEIGHTS MUST BE DETERMINED BY COMPARISON WITH OTHER WEIGHTS WHICH HAVE ACCEPTED MASS VALUES. THE 'UNKNOWN' WEIGHTS TOGETHER WITH 'CHECK STANDARDS', ARE GROUPED AND INTERCOMPARED ACCORDING TO THE DESIGN SCHEDULE GIVEN AT THE BEGINNING OF EACH SERIES OF WEIGHINGS. THE FIRST SERIES CONTAINS STANDARDS WHICH PROVIDE THE STARTING VALUES FOR THE SERIES OF WEIGHINGS AND PROVIDE THE TIE POINT FOR CONSISTENCY THROUGHOUT THE MEASUREMENT SYSTEM. THE WEIGHING METHOD USED, I.E., DOUBLE SUBSTITUTION, TRANSPOSITION, ETC., IS INDICATED ALONG WITH THE OBSERVED DATA. IN THE COMPUTATIONS, THE DISPLACEMENT VOLUMES ARE TREATED EXPLICITLY, USING THE DATA LISTED IN THE REPORT. IN ALL CASES, A REDUNDANCY IN THE NUMBER OF MEASUREMENTS PROVIDES A MEANS FOR CHECKING ON THE PRECISION OF THE PROCESS.

WHEN THERE ARE MORE EQUATIONS THAN 'UNKNOWNS', NOT ALL OBSERVATIONAL EQUATIONS CAN BE SATISFIED EXACTLY AND THE METHOD OF LEAST SQUARES IS USED TO PROVIDE ESTIMATES OF THE 'UNKNOWN' VALUES. THIS METHOD LEADS TO ESTIMATORS WHICH ARE LINEAR FUNCTIONS OF THE DATA AND WHICH HAVE STANDARD DEVIATIONS READILY CALCULATED FROM THE COEFFICIENTS OF THE LINEAR FUNCTIONS AND THE STANDARD DEVIATION OF AN INDIVIDUAL MEASUREMENT. THE 'CHECK STANDARD' IS ALSO TREATED AS AN UNKNOWN AND THE AGREEMENT OF THE CURRENT RESULT WITH THE ACCEPTED VALUE PROVIDES A TEST OF THE ADEQUACY OF THE CURRENT DATA. THIS SAME CHECK STANDARD IS MEASURED WITH EACH TEST OF UNKNOWNS AND THE COLLECTION OF VALUES OVER TIME IS USED TO EVALUATE THE PERFORMANCE OF THE MEASUREMENT PROCESS.

IN THE CASE OF THE SERIES WHICH INCLUDES THE KNOWN STANDARDS, THE ACCEPTED VALUES OF THESE STANDARDS SERVE AS A RESTRAINT ON THE SOLUTION OF THE EQUATIONS FOR THE VALUES OF ALL OF THE WEIGHTS. THE RESTRAINT FOR THE SOLUTION OF SUBSEQUENT SERIES IS PROVIDED BY THE VALUES ESTABLISHED FOR ONE OR MORE WEIGHTS INCLUDED IN A PREVIOUS SERIES.

ESTIMATED VALUES FOR WEIGHTS WHICH HAVE BEEN GROUPED IN THE SAME SERIES INVOLVE THE SAME OBSERVATIONAL DATA AND ARE, IN ALMOST ALL CASES, CORRELATED. FOR EACH SERIES THERE IS A TABLE OF COMBINATIONS TOGETHER WITH THE APPROPRIATE UNCERTAINTY FOR EACH COMBINATION.

PROCESS CONTROL

THE STANDARD DEVIATION, AS COMPUTED FROM THE LEAST SQUARES SOLUTION, PROVIDES A CHECK ON THE SHORT TERM, OR 'WITHIN-RUN' PROCESS PRECISION. AN AVERAGE OF A NUMBER OF THESE STANDARD DEVIATIONS IS TAKEN AS THE ACCEPTED WITHIN-RUN STANDARD DEVIATION OF THE PROCESS AND IS USED AS A REFERENCE VALUE FOR SURVEILLANCE OF THE PROCESS PRECISION. THE VALUES OBTAINED FOR THE 'CHECK STANDARD' PROVIDE, AS TIME GOES ON, A SEQUENCE OF VALUES THAT REALISTICALLY REFLECTS THE VARIATIONS WHICH BESET PRECISE MEASUREMENTS. COLLECTIONS OF VALUES FOR BOTH THE WITHIN-RUN PRECISION AND THE VALUE OBTAINED FOR THE 'CHECK STANDARD' SHOULD

POSSESS THE PROPERTIES CF RANDCM-NESS ASSOCIATED WITH INDEPENDENT MEASUREMENTS FROM A STABLE PROBABILITY DISTRIBUTICN. THE REPORTED 'F RATIO' AND 'T VALUE' ARE TESTS CF THE VALUES FROM THE CURRENT RUN FOR CCNFCRMITY TO THEIR RESPECTIVE DISTRIEUTIONS AND IF SATISFACTORY ARE TAKEN AS EVIDENCE THAT THE PROCESS IS IN CONTROL AND THAT PREDICTIVE STATEMENTS REGARDING UNCERTAINTY ARE VALID.

CONTROL CHARTS ON THE WITHIN-RUN PROCESS PRECISION AND THE VALUES OBTAINED FOR THE CHECK STANDARD ARE KEY ELEMENTS IN MONITORING THE STATE OF CONTROL OF ANY PRECISE MASS MEASUREMENT PROCESS. IN ADDITICN TC PROVIDING A BASIS FOR JUDGMENT AS TO THE ADEQUACY OF A GIVEN PRCCESS FCR A PARTICULAR REQUIREMENT, THESE DATA PROVIDE A MEANS TC JUDGE THE IMPCRTANCE OF LCNG TERM, CR 'BETWEEN-RUN' VARIABILITY WHICH CAN BE CHARACTERIZEC BY THE STANDARD DEVIATICN OF THE VALUES ABOUT THE MEAN. IF THERE IS AN ADDITICNAL COMPONENT CF VARIANCE ENTERING FRCM RUN TC RUN, THIS STANDARD DEVIATION WILL BE LARGER THAN CAN EE ACCOUNTED FOR BY THE WITHIN-RUN VARIABILITY. CORRELA-TION STUDIES, AS WELL AS SUPPLE-MENTAL EXPERIMENTS, ARE USED TO DETECT AND REDUCE THE MAGNITUDE OF SIGNIFICANT SYSTEMATIC EFFECTS. APPROPRIATE ACTION, E.G., ADDI-TICNAL EMPIRICAL CCRRECTIONS OR CHANGES IN TECHNIQUE, CAN REDUCE THE EFFECTS FRCM KNCWN SOURCES OF SYSTEMATIC VARIABILITY TO A MAGNITUDE WHICH IS NC LONGER IDENTIFIABLE IN THE DATA. IN THE CASES WHERE A SIGNIFICANT LCNG TERM, OR EETWEEN-RUN, COMFCNENT REMAINS THE UNCERTAINTY HAS BEEN APPROPRIATELY ADJUSTED.

SERIES OF MEASUREMENTS JUDGED AS OUT OF CONTROL RELATIVE TO THE APPROPRIATE PARAMETER ARE CARE-FULLY EXAMINED. IF RERUNS WERE NECESSARY IN THE COURSE OF THIS WORK, THE 'OUT OF CONTROL' SERIES, WITH REMARKS AS APPRCPRIATE, ARE ATTACHED AT THE END OF THE REPORT FOR YOUR INFORMATICN.

UNCERTAINTY

IT IS ASSUMED THAT THE PRESENT 'ACCEPTED VALUES' OF TWO NBS STAN-DARDS AT THE 1 KILOGRAM LEVEL, DESIGNATED N1 AND N2, ARE WITHOUT ERROR. ESTIMATES OF THE UNCER-TAINTY OF THE ACCEPTED VALUES OF THE NBS STANDARDS RELATIVE TO THE INTERNATICNAL PROTOTYPE KILOGRAM CAN BE PROVIDED ON REQUEST. HOWEVER, THESE ESTIMATES HAVE NO REAL MEANING IN EITHER NATIONAL OR INTERNATICNAL COMPARISCN. THIS IS BECAUSE OF THE LACK OF SUFFICIENT DATA TO PROVIDE A REALISTIC ESTIMATE OF THE UNCERTAINTY IN THE VALUES ASSIGNED TO THE PROTOTYPE KILOGRAMS K20 AND K4, PARTICULARLY IN REGARD TO LONG TERM, OR BETWEEN-RUN VARIABILITY. CHANGES IN THE ACCEPTED VALUES FCR THE NBS STANDARDS AT THE KILOGRAM LEVEL, AS AND WHEN THEY OCCUR, WILL BE REPORTED IN THE SCIENTIFIC PAPERS OF THE BUREAU AND WILL BE GIVEN WIDE DISTRIBUTION. IN CASES WHERE SUCH CHANGES MAY BE OF IMPORTANCE, OR WHERE CONTINUITY IS DESIRED, INSTRUCTICNS WILL BE INCLUDED FOR UP-DATING PREVIOUSLY REPORTED VALUES. WHEN THE VALUES REPORTED ARE BASED ON THE ACCEPTED VALUES OF STANDARDS OTHER THAN STANDARDS N1 AND N2 MENTIONED ABOVE, THE UNCERTAINTY OF THE ACCEPTED VALUE OF THE STANDARD BECOMES A SYSTEMATIC ERROR IN THE ASSIGNMENT OF VALUES TO OTHER STANCARDS AND IS INCLUDED IN THE REPORT.

A BALANCE UNDER STABLE OPERATING CONDITIONS WILL EXHIBIT A CERTAIN CHARACTERISTIC VARIABILITY WHICH CAN BE DESCRIBED BY THE STANDARD DEVIATION FOR SUCH MEASUREMENTS. THE VALUE FOR A PARTICULAR WEIGHT DETERMINED IN REPEATED TESTS WITH THE SAME WEIGHING DESIGN WILL HAVE ITS OWN STANDARD DEVIATION WHICH WILL BE SOME FUNCTION OF THE BALANCE PRECISION AND (POSSIBLY) OF THE BETWEEN-RUN COMPONENT. AS AN OUTER LIMIT OF THE DISTRIBUTION OF RANDOM ERRORS, THREE TIMES THE STANDARD DEVIATION IS USED. SYSTEMATIC ERRORS DUE TO THE PROCEDURES USED OR TO ENVIRONMENTAL EFFECTS ARE LARGELY BALANCED OUT AND CAN USUALLY BE REGARDED AS NEGLIGIBLE. WHEN A NON-NEGLIGIBLE BOUND TO THE POSSIBLE EFFECT FROM KNOWN SOURCES IS AVAILABLE, IT IS CALCULATED AND REPORTED SEPARATELY. E.G., THE UNCERTAINTY OF ACCEPTED VALUE AT OTHER THAN THE 1 KILOGRAM LEVEL. THE DISTRIBUTION IMPLIED BY THE RANDOM ERRORS MAY THUS BE CENTERED SOMEWHERE IN THE RANGE GIVEN BY THE BOUNDS TO THE SYSTEMATIC ERROR. THE TOTAL UNCERTAINTY IS TAKEN AS THE SUM OF THESE TWO COMPONENTS.

THE UNCERTAINTY ASSOCIATED WITH THE ASSIGNED VALUE CAN BE THOUGHT OF AS A BOUND TO THE DEPARTURE OF THE ASSIGNED VALUE FROM A HYPOTHETICAL AVERAGE VALUE THAT WOULD BE OBTAINED IF IT WERE POSSIBLE TO REPEAT THE MEASUREMENT MANY TIMES OVER A WIDE VARIETY OF CONDITIONS, E.G., SUBSTITUTE THE WEIGHT FOR ONE OF THE CHECK STANDARDS. THIS MEANS THAT THE UNCERTAINTY BAND CENTERED ON THE VALUES OBTAINED FROM EACH OF TWO MEASUREMENTS OF THE SAME OBJECT OVER SOME ARBITRARY TIME INTERVAL SHOULD ALMOST ALWAYS OVERLAP. IN OTHER WORDS, WHILE A SECOND MEASUREMENT WILL PRODUCE A DIFFERENT VALUE, THIS VALUE WILL ONLY RARELY DIFFER FROM THE FIRST VALUE BY MORE THAN THE SUM OF THE TWO UNCERTAINTIES. THE UNCERTAINTY BANDS ARE NOT EXPECTED TO OVERLAP IF SOME EVENT HAS OCCURRED IN THE TIME INTERVAL BETWEEN THE TWO MEASUREMENTS WHICH WILL CHANGE THE MASS OF THE OBJECT, E.G., ABRASIONS, ABUSE, CORROSION, IMPROPER CLEANING AND THE LIKE.

THE UNCERTAINTY IN ASSIGNED VALUE CONTAINED IN THIS REPORT BECOMES A SYSTEMATIC EFFECT FOR THE MEASUREMENT PROCESS IN WHICH THESE WEIGHTS ARE TO BE USED. IN THE ABSENCE OF OTHER SIGNIFICANT SYSTEMATIC EFFECTS IN THE USER'S MEASUREMENT PROCESS (A CONDITION WHICH MUST BE DEMONSTRATED) THE UNCERTAINTY OF THE VALUE ASSIGNED BY THE USER IS AN APPROPRIATE COMBINATION OF THE SYSTEMATIC ERROR IN THE STANDARD AND THE RANDOM COMPONENT ASSOCIATED WITH HIS PROCESS. IF THE MEASUREMENT PROCESSES ARE IN CONTROL AND APPROPRIATE UNCERTAINTIES ARE ASSIGNED, THE VALUES PRODUCED BY DIFFERENT MEASUREMENT FACILITIES WILL HAVE OVERLAPPING UNCERTAINTY BANDS AS DESCRIBED ABOVE. ONE CANNOT DISCUSS DIFFERENCES IN VALUES FOR THE SAME OBJECT OBTAINED BY DIFFERENT FACILITIES WITH ANY DEGREE OF SERIOUSNESS UNLESS EACH VALUE IS ACCOMPANIED BY A REALISTIC UNCERTAINTY STATEMENT.

REFERENCES

THE FOLLOWING REFERENCES ARE SUGGESTED FOR DETAILED DESCRIPTION OF PORTIONS OF THIS REPORT , AND FOR GENERAL INFORMATION CONCERNING THE MASS MEASUREMENT PROCESS:

1.PONTIUS, P. E., AND CAMERON, J. M.
REALISTIC UNCERTAINTIES AND THE MASS MEASUREMENT PROCESS
NAT. BUR. STAND. (U.S.), MONOGR. 103
(AUG. 15, 1967)

2.PONTIUS, P. E.
MEASUREMENT PHILOSOPHY OF THE PILOT PROGRAM FOR MASS CALIBRATION
NAT. BUR. STAND. (U.S.) TECH. NOTE 288
(MAY 6, 1966)

3.BOWMAN, H. A., AND SCHOONOVER, R. M. WITH APPENDIX BY MILDRED JONES
PROCEDURE FOR HIGH PRECISION DENSITY DETERMINATIONS BY HYDROSTATIC WEIGHING
J. RES. NAT. BUR. STAND. (U.S.) 71C. ENGINEERING AND INSTRUMENTATION
NO. 3, 179-198 (JULY-AUG. 1967)

4.NATRELLA, M. B.
EXPERIMENTAL STATISTICS
NAT. BUR. STAND. (U.S.) HANDBOOK 91
(AUGUST 1, 1963)

5.KU, H. H.
PRECISION MEASUREMENT AND CALIBRATION - SELECTED NBS PAPERS ON STATISTICAL CONCEPTS AND PROCEDURES
NAT. BUR. STAND. (U.S.) SPEC. PUBL. 300
VOL. 1 (FEB. 1969)

6.PONTIUS, P. E.
MASS AND MASS VALUES
NAT. BUR. STAND. (U.S.) MONOGR. 133
(JAN. 1974)

7.CAMERON, J. M., CROARKIN, C. C. AND RAYBOLD, R. C.
DESIGNS FOR THE CALIBRATION OF STANDARDS OF MASS
NAT. BUR. STAND. (U.S.) TECH. NOTE 952
(JUNE 1977)

8.VARNER, R. N., AND RAYBOLD, R. C.
NATIONAL BUREAU OF STANDARDS MASS CALIBRATION COMPUTER SOFTWARE
NAT. BUR. STAND. (U.S.) TECH. NOTE
(IN PROCESS)

SOMEWHERE, U.S.A.
SET OF MASS STANDARDS : 5KG - 100MG
TEST NUMBER 654321
TO BE PUELISHED:

9.PONTILS, P. E.
THE ACCEPTED VALUES AND ASSCCIATED UNCERTAINTY ESTIMATES CF THE NBS STANDARDS AT THE 1 KG LEVEL
NAT. BUR. STAND. (U.S.) TECH. NOTE
(EXPECTED CCMPLETICN: 1975)

10.PONTIUS, P. E.
DOCUMENTATICN FOR THE MASS MEASUREMENT PROCESS AT NBS
NAT. EUR. STAND. (U.S.) TECH. NOTE
(EXPECTED CCMPLETICN: 1974)

BALANCE 1
OPERATOR 84
ACCEPTED WITHIN STANDARD DEVIATION OF THE PROCESS 1.15000 MG
ACCEPTED BETWEEN STANDARD DEVIATION OF THE PROCESS .00000 MG

CALIBRATION DESIGN 53
RESTRAINT VECTOR 0 0 0 1 1
MASS CORRECTION OF RESTRAINT 23.06600 MG
VOLUME OF WEIGHTS BEING USED IN RESTRAINT AT 22.10 C 249.82820 CM3
SYSTEMATIC ERROR IN THE RESTRAINT .07600 MG
3 STANDARD DEVIATION LIMIT FOR RANDOM ERROR AFFECTING RESTRAINT .00000 MG

CHECK STANDARD USED 2
CHECK STANDARD VECTOR 0 0 0 1 -1
ACCEPTED MASS CORRECTION OF CHECK STANDARD -.58400 MG
REPORT VECTOR 1 1 1 0 0

TEST CONDITIONS	BEFORE	AFTER	AVERAGE
CORRECTED TEMPERATURE IN DEGREES C	21.98	22.22	22.10
CORRECTED PRESSURE IN MM HG	733.680	734.080	733.880
CORRECTED HUMIDITY IN PERCENT	41.00	41.00	41.00
COMPUTED AIR DENSITY IN MG/CM3	1.1505	1.1501	1.1503
TEMPERATURE CORRECTION	.000	.000	
PRESSURE CORRECTION	.000	.000	
HUMIDITY CORRECTION	.00	.00	
OBSERVED TEMPERATURE IN DEGREES C	21.98	22.22	
OBSERVED PRESSURE IN MM HG	733.680	734.080	
OBSERVED HUMIDITY IN PERCENT	41.00	41.00	

WEIGHTS BEING TESTED	NOMINAL VALUE G	DENSITY G/CM3 AT 20C	COEFFICIENT OF EXPANSION	ACCEPTED CORRECTION MG
5KG	5000.0000	7.9530	.000045	
3KG	3000.0000	7.9530	.000045	
2KG	2000.0000	7.9000	.000045	
S 1KG-1	1000.0000	8.0064	.000045	11.24100
S 1KG-2	1000.0000	8.0063	.000045	11.82500

BALANCE 1
OPERATOR 84

CALIBRATION DESIGN 53

		GRAMS 5000	3000	2000	1000	1000
A	1	+	-	-	+	-
A	2	-	+	+	+	-
A	3	+	-	-		
A	4	-	+		+	+
A	5		-	+	+	
A	6		+	-		-
A	7			+	-	-
A	8				+	-
R					+	+

OBSERVATIONS IN DIVISIONS
SINGLE TRANSPOSITION TWO PAN BALANCE

A	1	4.7000	15.2000	5.0000	5.4000	12.5000	5.5000
		7.3000	15.0000	7.4000			
A	2	5.8000	12.4000	6.2000	5.6000	14.1000	5.9000
		7.8000	16.4000	8.2000			
A	3	6.4000	13.6000	6.5000	4.4000	13.4000	4.5000
		7.2000	15.2000	7.3000			
A	4	4.8000	13.4000	5.0000	5.4000	15.2000	5.7000
		7.3000	17.4000	7.6000			
A	5	6.0000	14.8000	6.3000	5.3000	13.0000	5.4000
		6.7000	16.0000	7.0000			
A	6	5.2000	13.0000	5.3000	5.4000	16.0000	5.6000
		9.2000	16.5000	9.3000			
A	7	5.9000	14.0000	6.2000	5.9000	13.4000	6.2000
		7.8000	16.2000	8.0000			
A	8	5.9000	13.9000	6.1000	5.0000	14.8000	5.2000
		8.6000	15.8000	8.6000			

BALANCE 1
OPERATOR 84

CALIBRATION DESIGN 53

SENSITIVITY WEIGHT
MASS 49.98277 MG
VOLUME .00301 CM3 AT 20 C
COEFFICIENT OF EXPANSION .000020
S*=S-PV(S)= 49.97931 MG

			A(I) (MG)	DELTA(I) (MG)	AVERAGE SENSITIVITY (MG/DIV)	ZERO(I) (DIV)	OBSERVED SENSITIVITY (MG/DIV)
A	1		11.72699	.39524	22.33712	9.50000	22.71787
A	2		-8.09721	2.22116	22.33712	9.56250	21.96893
A	3		12.63844	1.81339	22.97899	9.47500	21.73013
A	4		-14.07463	-.01255	22.97899	9.76250	24.38015
A	5		14.85099	-2.10971	22.84768	9.82500	22.21303
A	6	*	-18.56374	-2.10973	22.84768	9.93750	23.51967
A	7		3.22447	-.01255	21.49648	9.87500	21.49648
A	8		.00000	-.50669	22.21302	9.95000	22.21302

* OBSERVED DEFLECTION IS GREATER THAN OR EQUAL TO ONE FOURTH THE SENSITIVITY DEFLECTION

ITEM (G)	CORRECTION (MG)	VOLUME (AT T) (CM3)	SYSTEMATIC ERROR (MG)	3 S.D. LIMIT (MG)	UNCERTAINTY LIMIT (MG)
5000.0000	63.07702	628.76090	.19000	5.45493	5.64493
3000.0000	24.01883	377.25480	.11400	3.57109	3.68509
2000.0000	30.17279	253.19230	.07600	2.60795	2.68395
1000.0000	11.78548	124.91335	.03800	.92205	.96005
1000.0000	11.28052	124.91485	.03800	.92205	.96005

TEMPERATURE T= 22.10 C

RESTRAINT FOR FOLLOWING SERIES
RESTRAINT VECTOR 0 0 0 1 1
MASS CORRECTION 23.06600 MG
VOLUME AT 20 C 249.80460 CM3
SYSTEMATIC ERROR .07600 MG
3 STANDARD DEVIATION LIMIT .00000 MG

BALANCE 1
OPERATOR 84
MAXIMUM LOAD 6000.0000 G
STARTING RESTRAINT NUMBER 80

CALIBRATION DESIGN 53

PRECISION CONTROL

OBSERVED STANDARD DEVIATION OF THE PROCESS 2.09386 MG
ACCEPTED STANDARD DEVIATION OF THE PROCESS 1.15000 MG
DEGREES OF FREEDOM 4
F RATIO 3.315

F RATIO IS LESS THAN 3.33 (CRITICAL VALUE FOR PROBABILITY = .01).
THEREFORE THE STANDARD DEVIATION IS IN CONTROL.

CHECK STANDARD VECTOR 0 0 0 1 -1
CHECK STANDARD USED 2
ACCEPTED MASS CORRECTION OF CHECK STANDARD -.58400 MG
OBSERVED CORRECTION OF CHECK STANDARD .50497 MG
STANDARD DEVIATION OF THE OBSERVED CORRECTION .61470 MG
T VALUE 1.77

ABSOLUTE VALUE OF T IS LESS THAN 3.
THEREFORE CHECK STANDARD IS IN CONTROL.

TEST CONDITIONS	BEFORE	AFTER	AVERAGE
CORRECTED TEMPERATURE IN DEGREES C	21.98	22.22	22.10
CORRECTED PRESSURE IN MM HG	733.680	734.080	733.880
CORRECTED HUMIDITY IN PERCENT	41.00	41.00	41.00
COMPUTED AIR DENSITY IN MG/CM3	1.1505	1.1501	1.1503
TEMPERATURE CORRECTION	.000	.000	
PRESSURE CORRECTION	.000	.000	
HUMIDITY CORRECTION	.00	.00	
OBSERVED TEMPERATURE IN DEGREES C	21.98	22.22	
OBSERVED PRESSURE IN MM HG	733.680	734.080	
OBSERVED HUMIDITY IN PERCENT	41.00	41.00	

BALANCE 3
OPERATOR 84
ACCEPTED WITHIN STANDARD DEVIATION OF THE PROCESS .02800 MG
ACCEPTED BETWEEN STANDARD DEVIATION OF THE PROCESS .00000 MG

CALIBRATION DESIGN 41
RESTRAINT VECTOR 1 1 0 0
MASS CORRECTION OF RESTRAINT 23.06600 MG
VOLUME OF WEIGHTS BEING USED IN RESTRAINT AT 21.91 C 249.82613 CM3
SYSTEMATIC ERROR IN THE RESTRAINT .07600 MG
3 STANDARD DEVIATION LIMIT FOR RANDOM ERROR AFFECTING RESTRAINT .00000 MG

CHECK STANDARD USED 2
CHECK STANDARD VECTOR 1 -1 0 0
ACCEPTED MASS CORRECTION OF CHECK STANDARD -.58400 MG
REPORT VECTOR 0 0 1 0

TEST CONDITIONS	BEFORE	AFTER	AVERAGE
CORRECTED TEMPERATURE IN DEGREES C	21.91	21.92	21.91
CORRECTED PRESSURE IN MM HG	736.860	736.760	736.810
CORRECTED HUMIDITY IN PERCENT	40.00	40.00	40.00
COMPUTED AIR DENSITY IN MG/CM3	1.1559	1.1557	1.1558
TEMPERATURE CORRECTION	.000	.000	
PRESSURE CORRECTION	.000	.000	
HUMIDITY CORRECTION	.00	.00	
OBSERVED TEMPERATURE IN DEGREES C	21.91	21.92	
OBSERVED PRESSURE IN MM HG	736.860	736.760	
OBSERVED HUMIDITY IN PERCENT	40.00	40.00	

WEIGHTS BEING TESTED	NOMINAL VALUE G	DENSITY G/CM3 AT 20C	COEFFICIENT OF EXPANSION	ACCEPTED CORRECTION MG
S 1KG-1	1000.0000	8.0064	.000045	11.24100
S 1KG-2	1000.0000	8.0063	.000045	11.82500
1KG	1000.0000	7.9530	.000045	
SUM 1KG	1000.0000	7.9264	.000045	

BALANCE 3
OPERATOR 84

CALIBRATION DESIGN 41

		GRAMS 1000	1000	1000	1000
A	1	+	-		
A	2	+		-	
A	3	+			-
A	4		+	-	
A	5		+		-
A	6			+	-
R		+	+		

OBSERVATIONS IN DIVISIONS
DOUBLE SUBSTITUTION ONE PAN BALANCE

A	1	16.7400	17.3400	67.3700	66.7300
A	2	16.8500	11.2400	61.1800	66.7700
A	3	16.8400	13.1700	63.1100	66.7600
A	4	17.3200	11.1300	61.0600	67.2300
A	5	17.2200	13.0200	62.9300	67.1600
A	6	10.9200	12.8200	62.8600	60.8400

BALANCE 3
OPERATOR 84

CALIBRATION DESIGN 41

SENSITIVITY WEIGHT
MASS 49.98277 MG
VOLUME .00301 CM3 AT 20 C
COEFFICIENT OF EXPANSION .000020
S*=S-PV(S)= 49.97929 MG

		A(I) (MG)	DELTA(I) (MG)	AVERAGE SENSITIVITY (MG/DIV)	DRIFT(I) (MG)	OBSERVED SENSITIVITY (MG/DIV)
A	1	-.61998	-.02625	.99997	-.02000	.99859
A	2	5.59983	.00501	.99997	-.01000	1.00059
A	3	3.65989	.02125	.99997	-.01000	1.00059
A	4	6.17981	-.00875	.99997	-.01000	1.00079
A	5	4.21487	-.01750	.99997	.01500	1.00169
A	6	-1.95994	-.00375	.99997	-.06000	.99759

ITEM (G)	CORRECTION (MG)	VOLUME (AT T) (CM3)	SYSTEMATIC ERROR (MG)	3 S.D. LIMIT (MG)	UNCERTAINTY LIMIT (MG)
1000.0000	11.23519	124.91225	.03800	.02970	.06770
1000.0000	11.83082	124.91388	.03800	.02970	.06770
1000.0000	6.60911	125.75038	.03800	.05144	.08944
1000.0000	9.05323	126.17253	.03800	.05144	.08944

TEMPERATURE T= 21.91 C

RESTRAINT FOR FOLLOWING SERIES
RESTRAINT VECTOR 0 0 0 1
MASS CORRECTION 9.05323 MG
VOLUME AT 20 C 126.16166 CM3
SYSTEMATIC ERROR .03800 MG
3 STANDARD DEVIATION LIMIT .05144 MG

BALANCE 3
OPERATOR 84
MAXIMUM LOAD 1000.0000 G
STARTING RESTRAINT NUMBER 80

CALIBRATION DESIGN 41

PRECISION CONTROL

OBSERVED STANDARD DEVIATION OF THE PROCESS	.02282	MG
ACCEPTED STANDARD DEVIATION OF THE PROCESS	.02800	MG
DEGREES OF FREEDOM	3	
F RATIO	.664	

F RATIO IS LESS THAN 3.79 (CRITICAL VALUE FOR PROBABILITY = .01).
THEREFORE THE STANDARD DEVIATION IS IN CONTROL.

CHECK STANDARD VECTOR	1	-1	0	0
CHECK STANDARD USED	2			

ACCEPTED MASS CORRECTION OF CHECK STANDARD	-.58400	MG
OBSERVED CORRECTION OF CHECK STANDARD	-.59562	MG
STANDARD DEVIATION OF THE OBSERVED CORRECTION	.01980	MG
T VALUE	-.59	

ABSOLUTE VALUE OF T IS LESS THAN 3.
THEREFORE CHECK STANDARD IS IN CONTROL.

TEST CONDITIONS	BEFORE	AFTER	AVERAGE
CORRECTED TEMPERATURE IN DEGREES C	21.91	21.92	21.91
CORRECTED PRESSURE IN MM HG	736.860	736.760	736.810
CORRECTED HUMIDITY IN PERCENT	40.00	40.00	40.00
COMPUTED AIR DENSITY IN MG/CM3	1.1559	1.1557	1.1558
TEMPERATURE CORRECTION	.000	.000	
PRESSURE CORRECTION	.000	.000	
HUMIDITY CORRECTION	.00	.00	
OBSERVED TEMPERATURE IN DEGREES C	21.91	21.92	
OBSERVED PRESSURE IN MM HG	736.860	736.760	
OBSERVED HUMIDITY IN PERCENT	40.00	40.00	

BALANCE 3
OPERATOR 84
ACCEPTED WITHIN STANDARD DEVIATION OF THE PROCESS .02800 MG
ACCEPTED BETWEEN STANDARD DEVIATION OF THE PROCESS .00000 MG

CALIBRATION DESIGN 62
RESTRAINT VECTOR 1 1 1 0 0 0
MASS CORRECTION OF RESTRAINT 9.05323 MG
VOLUME OF WEIGHTS BEING USED IN RESTRAINT AT 21.94 C 126.17267 CM3
SYSTEMATIC ERROR IN THE RESTRAINT .03800 MG
3 STANDARD DEVIATION LIMIT FOR RANDOM ERROR AFFECTING RESTRAINT .05144 MG

CHECK STANDARD USED 4
CHECK STANDARD VECTOR 0 0 0 0 1 0
ACCEPTED MASS CORRECTION OF CHECK STANDARD .98830 MG
REPORT VECTOR 1 1 1 1 0 0

TEST CONDITIONS	BEFORE	AFTER	AVERAGE
CORRECTED TEMPERATURE IN DEGREES C	21.92	21.96	21.94
CORRECTED PRESSURE IN MM HG	736.920	736.580	736.750
CORRECTED HUMIDITY IN PERCENT	40.00	40.00	40.00
COMPUTED AIR DENSITY IN MG/CM3	1.1560	1.1553	1.1556
TEMPERATURE CORRECTION	.000	.000	
PRESSURE CORRECTION	.000	.000	
HUMIDITY CORRECTION	.00	.00	
OBSERVED TEMPERATURE IN DEGREES C	21.92	21.96	
OBSERVED PRESSURE IN MM HG	736.920	736.580	
OBSERVED HUMIDITY IN PERCENT	40.00	40.00	

WEIGHTS BEING TESTED	NOMINAL VALUE G	DENSITY G/CM3 AT 20C	COEFFICIENT OF EXPANSION	ACCEPTED CORRECTION MG
500G	500.0000	7.9000	.000045	
300G	300.0000	7.9530	.000045	
200G	200.0000	7.9530	.000045	
100G	100.0000	7.9000	.000045	
S 100G	100.0000	7.9530	.000045	.98830
SUM 100G	100.0000	7.9423	.000045	

BALANCE 3
OPERATOR 84

CALIBRATION DESIGN 62

	GRAMS 500	300	200	100	100	100
A 1	+	-	-	+	-	
A 2	+	-	-		+	-
A 3	+	-	-	-		+
A 4	+	-	-			
A 5	+		-	-	-	-
A 6		+	-	+	-	-
A 7		+	-	-	+	-
A 8		+	-	-	-	+
A 9			+	-	-	
A 10			+	-		-
A 11			+		-	-
R	+	+	+			

OBSERVATIONS IN DIVISIONS
DOUBLE SUBSTITUTION ONE PAN BALANCE

A 1	12.7800	10.6200	60.6300	62.8600
A 2	13.0200	12.5900	62.5400	62.9600
A 3	14.8600	10.7500	60.7300	64.8800
A 4	12.8600	10.6100	60.5400	62.8200
A 5	12.9100	13.5800	63.5400	62.8100
A 6	10.8700	13.4400	63.3300	60.8400
A 7	10.9400	13.3300	63.2600	60.8200
A 8	12.6900	11.4400	61.3800	62.6600
A 9	11.1800	11.7100	61.6800	61.1400
A 10	11.1800	13.5000	63.3800	61.1100
A 11	11.0900	13.4400	63.4000	60.9600

BALANCE 3
OPERATOR 84

CALIBRATION DESIGN 62

SENSITIVITY WEIGHT
MASS 49.98277 MG
VOLUME .00301 CM3 AT 20 C
COEFFICIENT OF EXPANSION .000020
S*=S-PV(S)= 49.97929 MG

	A(I) (MG)	DELTA(I) (MG)	AVERAGE SENSITIVITY (MG/DIV)	DRIFT(I) (MG)	OBSERVED SENSITIVITY (MG/DIV)
A 1	2.19570	.00092	1.00032	.03501	1.00009
A 2	.42514	-.00556	1.00032	-.00500	1.00049
A 3	4.13132	-.01335	1.00032	.02001	1.00039
A 4	2.26621	.00950	1.00054	.01501	1.00129
A 5	-.70038	.00849	1.00054	-.03002	.99979
A 6	-2.53351	-.00805	1.00139	.04006	1.00259
A 7	-2.41835	-.01675	1.00139	-.02503	1.00049
A 8	1.26676	.01632	1.00139	.01502	1.00109
A 9	-.53537	-.03332	1.00069	-.00500	1.00009
A 10	-2.29658	.03149	1.00069	.02502	1.00249
A 11	-2.39664	-.00665	1.00069	-.04503	.99949

ITEM (G)	CORRECTION (MG)	VOLUME (AT T) (CM3)	SYSTEMATIC ERROR (MG)	3 S.D. LIMIT (MG)	UNCERTAINTY LIMIT (MG)
500.0000	5.89889	63.29741	.01900	.03233	.05133
300.0000	1.75036	37.72513	.01140	.02945	.04085
200.0000	1.40395	25.15011	.00760	.02443	.03203
100.0000	1.01957	12.65946	.00380	.03027	.03407
100.0000	.98400	12.57509	.00380	.03027	.03407
100.0000	2.82980	12.59220	.00380	.03027	.03407

TEMPERATURE T= 21.94 C

RESTRAINT FOR FOLLOWING SERIES
RESTRAINT VECTOR 0 0 0 0 0 1
MASS CORRECTION 2.82980 MG
VOLUME AT 20 C 12.59110 CM3
SYSTEMATIC ERROR .00380 MG
3 STANDARD DEVIATION LIMIT .03027 MG

BALANCE 3
OPERATOR 84

CALIBRATION DESIGN 62

SUM (G)	WEIGHTS USED FOR THE LINEAR COMBINATIONS GRAMS					
	500	300	200	100	100	100
600	+			+		

VALUES AND UNCERTAINTIES FOR COMBINATIONS OF WEIGHTS
(UNCERTAINTY IS 3 STANDARD DEVIATION LIMIT PLUS ALLOWANCE FOR SYSTEMATIC ERROR.)

SUM (G)	CORR (MG)	SYSTEMATIC (MG)	3 S.D. ERROR (MG)	UNCERTAINTY LIMIT (MG)
600	6.91847	.02280	.04750	.07030

BALANCE 3
OPERATOR 84
MAXIMUM LOAD 600.0000 G
STARTING RESTRAINT NUMBER 80

CALIBRATION DESIGN 62

PRECISION CONTROL

OBSERVED STANDARD DEVIATION OF THE PROCESS .02284 MG
ACCEPTED STANDARD DEVIATION OF THE PROCESS .02800 MG
DEGREES OF FREEDOM 6
F RATIO .665

F RATIO IS LESS THAN 2.81 (CRITICAL VALUE FOR PROBABILITY = .01).
THEREFORE THE STANDARD DEVIATION IS IN CONTROL.

CHECK STANDARD VECTOR 0 0 0 0 1 0
CHECK STANDARD USED 4
ACCEPTED MASS CORRECTION OF CHECK STANDARD .98830 MG
OBSERVED CORRECTION OF CHECK STANDARD .98400 MG
STANDARD DEVIATION OF THE OBSERVED CORRECTION .01009 MG
T VALUE -.43

ABSOLUTE VALUE OF T IS LESS THAN 3.
THEREFORE CHECK STANDARD IS IN CONTROL.

TEST CONDITIONS	BEFORE	AFTER	AVERAGE
CORRECTED TEMPERATURE IN DEGREES C	21.92	21.96	21.94
CORRECTED PRESSURE IN MM HG	736.920	736.580	736.750
CORRECTED HUMIDITY IN PERCENT	40.00	40.00	40.00
COMPUTED AIR DENSITY IN MG/CM3	1.1560	1.1553	1.1556
TEMPERATURE CORRECTION	.000	.000	
PRESSURE CORRECTION	.000	.000	
HUMIDITY CORRECTION	.00	.00	
OBSERVED TEMPERATURE IN DEGREES C	21.92	21.96	
OBSERVED PRESSURE IN MM HG	736.920	736.580	
OBSERVED HUMIDITY IN PERCENT	40.00	40.00	

BALANCE 5
OPERATOR 84
ACCEPTED WITHIN STANDARD DEVIATION OF THE PROCESS .01200 MG
ACCEPTED BETWEEN STANDARD DEVIATION OF THE PROCESS .00000 MG

CALIBRATION DESIGN 62
RESTRAINT VECTOR 1 1 1 0 0 0
MASS CORRECTION OF RESTRAINT 2.82980 MG
VOLUME OF WEIGHTS BEING USED IN RESTRAINT AT 21.97 C 12.59222 CM3
SYSTEMATIC ERROR IN THE RESTRAINT .00380 MG
3 STANDARD DEVIATION LIMIT FOR RANDOM ERROR AFFECTING RESTRAINT .03027 MG

CHECK STANDARD USED 6
CHECK STANDARD VECTOR 0 0 0 0 1 0
ACCEPTED MASS CORRECTION OF CHECK STANDARD .07850 MG
REPORT VECTOR 1 1 1 1 0 0

TEST CONDITIONS	BEFORE	AFTER	AVERAGE
CORRECTED TEMPERATURE IN DEGREES C	21.99	21.96	21.97
CORRECTED PRESSURE IN MM HG	746.600	746.000	746.300
CORRECTED HUMIDITY IN PERCENT	31.00	31.00	31.00
COMPUTED AIR DENSITY IN MG/CM3	1.1720	1.1712	1.1716
TEMPERATURE CORRECTION	.000	.000	
PRESSURE CORRECTION	.000	.000	
HUMIDITY CORRECTION	.00	.00	
OBSERVED TEMPERATURE IN DEGREES C	21.99	21.96	
OBSERVED PRESSURE IN MM HG	746.600	746.000	
OBSERVED HUMIDITY IN PERCENT	31.00	31.00	

WEIGHTS BEING TESTED	NOMINAL VALUE G	DENSITY G/CM3 AT 20C	COEFFICIENT OF EXPANSION	ACCEPTED CORRECTION MG
50G	50.0000	7.9530	.000045	
30G	30.0000	7.9530	.000045	
20G	20.0000	7.9000	.000045	
10G	10.0000	7.9530	.000045	
S 10G	10.0000	7.9530	.000045	.07850
SUM 10G	10.0000	7.9264	.000045	

BALANCE 5
OPERATOR 84

CALIBRATION DESIGN 62

	GRAMS 50	30	20	10	10	10
A 1	+	-	-	+	-	
A 2	+	-	-		+	-
A 3	+	-	-	-		+
A 4	+	-	-			
A 5	+		-	-	-	-
A 6		+	-	+	-	-
A 7		+	-	-	+	-
A 8		+	-	-	-	+
A 9			+	-	-	
A 10			+	-		-
A 11			+		-	-
R	+	+	+			

OBSERVATIONS IN DIVISIONS
DOUBLE SUBSTITUTION ONE PAN BALANCE

A 1	6.1800	4.6900	54.7100	56.2000
A 2	6.1700	4.7200	54.7100	56.1500
A 3	6.1400	4.7600	54.7600	56.1400
A 4	6.1900	4.7400	54.7200	56.1800
A 5	6.1800	4.4700	54.4500	56.1800
A 6	4.8100	4.4400	54.4400	54.8100
A 7	4.7900	4.4900	54.4700	54.7500
A 8	4.7600	4.5100	54.4900	54.7400
A 9	4.5200	4.5500	54.5200	54.4900
A 10	4.4800	4.5200	54.5000	54.4700
A 11	4.4700	4.4700	54.4600	54.4700

X Y Z CORPORATION
SOMEWHERE, U.S.A.
SET OF MASS STANDARDS : 5KG - 100MG
TEST NUMBER 654321

BALANCE 5
OPERATOR 84

CALIBRATION DESIGN 62

SENSITIVITY WEIGHT
MASS 49.98277 MG
VOLUME .00301 CM3 AT 20 C
COEFFICIENT OF EXPANSION .000020
S*=S-PV(S)= 49.97924 MG

	A(I) (MG)	DELTA(I) (MG)	AVERAGE SENSITIVITY (MG/DIV)	DRIFT(I) (MG)	OBSERVED SENSITIVITY (MG/DIV)
A 1	1.48923	.00353	.99948	.00000	.99919
A 2	1.44426	-.00895	.99948	-.00500	.99968
A 3	1.37929	-.00582	.99948	.00000	.99958
A 4	1.45520	.01386	1.00013	.00500	1.00008
A 5	1.72023	-.00262	1.00013	.01000	1.00018
A 6	.36992	.00046	.99978	.00000	.99958
A 7	.28994	.00920	.99978	-.01000	.99978
A 8	.24995	-.00704	.99978	.00000	.99998
A 9	-.03000	.01358	1.00005	-.00000	1.00018
A 10	-.03500	-.00330	1.00005	.00500	1.00008
A 11	.00500	-.00766	1.00005	.00500	.99988

ITEM (G)	CORRECTION (MG)	VOLUME (AT T) (CM3)	SYSTEMATIC ERROR (MG)	3 S.D. LIMIT (MG)	UNCERTAINTY LIMIT (MG)
50.0000	2.12579	6.28776	.00190	.01731	.01921
30.0000	.53569	3.77256	.00114	.01407	.01521
20.0000	.16831	2.53189	.00076	.01126	.01202
10.0000	.11825	1.25751	.00038	.01314	.01352
10.0000	.07388	1.25751	.00038	.01314	.01352
10.0000	.06695	1.26173	.00038	.01314	.01352

TEMPERATURE T= 21.97 C

RESTRAINT FOR FOLLOWING SERIES
RESTRAINT VECTOR 0 0 0 0 0 1
MASS CORRECTION .06695 MG
VOLUME AT 20 C 1.26161 CM3
SYSTEMATIC ERROR .00038 MG
3 STANDARD DEVIATION LIMIT .01314 MG

BALANCE 5
OPERATOR 84
MAXIMUM LOAD 60.0000 G
STARTING RESTRAINT NUMBER 80

CALIBRATION DESIGN 62

PRECISION CONTROL

OBSERVED STANDARD DEVIATION OF THE PROCESS .01091 MG
ACCEPTED STANDARD DEVIATION OF THE PROCESS .01200 MG
DEGREES OF FREEDOM 6
F RATIO .826

F RATIO IS LESS THAN 2.81 (CRITICAL VALUE FOR PROBABILITY = .01).
THEREFORE THE STANDARD DEVIATION IS IN CONTROL.

CHECK STANDARD VECTOR 0 0 0 0 1 0
CHECK STANDARD USED 6
ACCEPTED MASS CORRECTION OF CHECK STANDARD .07850 MG
OBSERVED CORRECTION OF CHECK STANDARD .07388 MG
STANDARD DEVIATION OF THE OBSERVED CORRECTION .00438 MG
T VALUE -1.06

ABSOLUTE VALUE OF T IS LESS THAN 3.
THEREFORE CHECK STANDARD IS IN CONTROL.

TEST CONDITIONS	BEFORE	AFTER	AVERAGE
CORRECTED TEMPERATURE IN DEGREES C	21.99	21.96	21.97
CORRECTED PRESSURE IN MM HG	746.600	746.000	746.300
CORRECTED HUMIDITY IN PERCENT	31.00	31.00	31.00
COMPUTED AIR DENSITY IN MG/CM3	1.1720	1.1712	1.1716
TEMPERATURE CORRECTION	.000	.000	
PRESSURE CORRECTION	.000	.000	
HUMIDITY CORRECTION	.00	.00	
OBSERVED TEMPERATURE IN DEGREES C	21.99	21.96	
OBSERVED PRESSURE IN MM HG	746.600	746.000	
OBSERVED HUMIDITY IN PERCENT	31.00	31.00	

BALANCE 7
OPERATOR 84
ACCEPTED WITHIN STANDARD DEVIATION OF THE PROCESS .00170 MG
ACCEPTED BETWEEN STANDARD DEVIATION OF THE PROCESS .00000 MG

CALIBRATION DESIGN 62
RESTRAINT VECTOR 1 1 1 0 0 0
MASS CORRECTION OF RESTRAINT .06695 MG
VOLUME OF WEIGHTS BEING USED IN RESTRAINT AT 21.90 C 1.26172 CM3
SYSTEMATIC ERROR IN THE RESTRAINT .00038 MG
3 STANDARD DEVIATION LIMIT FOR RANDOM ERROR AFFECTING RESTRAINT .01314 MG

CHECK STANDARD USED 8
CHECK STANDARD VECTOR 0 0 0 0 1 0
ACCEPTED MASS CORRECTION OF CHECK STANDARD -.07920 MG
REPORT VECTOR 1 1 1 1 0 0

TEST CONDITIONS	BEFORE	AFTER	AVERAGE
CORRECTED TEMPERATURE IN DEGREES C	21.92	21.88	21.90
CORRECTED PRESSURE IN MM HG	743.280	742.820	743.050
CORRECTED HUMIDITY IN PERCENT	35.00	35.00	35.00
COMPUTED AIR DENSITY IN MG/CM3	1.1666	1.1660	1.1663
TEMPERATURE CORRECTION	.000	.000	
PRESSURE CORRECTION	.000	.000	
HUMIDITY CORRECTION	.00	.00	
OBSERVED TEMPERATURE IN DEGREES C	21.92	21.88	
OBSERVED PRESSURE IN MM HG	743.280	742.820	
OBSERVED HUMIDITY IN PERCENT	35.00	35.00	

WEIGHTS BEING TESTED	NOMINAL VALUE G	DENSITY G/CM3 AT 20C	COEFFICIENT OF EXPANSION	ACCEPTED CORRECTION MG
5G	5.0000	7.9000	.000045	
3G	3.0000	7.9530	.000045	
2G	2.0000	7.9530	.000045	
1G	1.0000	7.9000	.000045	
S 1G	1.0000	7.9530	.000045	-.07920
SUM 1G	1.0000	16.6000	.000020	

BALANCE 7
OPERATOR 84

CALIBRATICN DESIGN 62

	GRAMS 5	3	2	1	1	1
A 1	+	-	-	+	-	
A 2	+	-	-		+	-
A 3	+	-	-	-		+
A 4	+	-	-			
A 5	+		-	-	-	-
A 6		+	-	+	-	-
A 7		+	-	-	+	-
A 8		+	-	-	-	+
A 9			+	-	-	
A 10			+	-		-
A 11			+		-	-
R	+	+	+			

OBSERVATIONS IN DIVISIONS
DOUBLE SUESTITUTION ONE PAN BALANCE

A 1	1.0840	.9260	5.9270	6.0840
A 2	.9780	.9390	5.9310	5.9720
A 3	.9900	1.0210	6.0210	5.9870
A 4	1.0680	1.0130	6.0090	6.0670
A 5	1.0680	.8750	5.8700	6.0630
A 6	1.0620	.8620	5.8570	6.0530
A 7	.9590	.9660	5.9570	5.9480
A 8	.9690	.9480	5.9420	5.9600
A 9	1.0160	.9760	5.9660	6.0060
A 10	1.0160	.9870	5.9810	6.0060
A 11	1.0120	.8810	5.8720	6.0040

X Y Z CORPORATION
SOMEWHERE, U.S.A.
SET OF MASS STANDARDS : 5KG - 100MG
TEST NUMBER 654321

BALANCE 7
OPERATOR 84

CALIBRATION DESIGN 62

SENSITIVITY WEIGHT
MASS 5.00171 MG
VOLUME .00185 CM3 AT 20 C
COEFFICIENT OF EXPANSION .000069
S*=S-PV(S)= 4.99955 MG

	A(I) (MG)	DELTA(I) (MG)	AVERAGE SENSITIVITY (MG/DIV)	DRIFT(I) (MG)	OBSERVED SENSITIVITY (MG/DIV)
A 1	.15755	-.00114	1.00031	-.00050	.99961
A 2	.04001	-.00146	1.00031	.00100	1.00171
A 3	-.03251	.00082	1.00031	-.00150	.99961
A 4	.05655	.00094	1.00096	.00150	1.00101
A 5	.19319	.00085	1.00096	.00000	1.00091
A 6	.19819	-.00001	1.00094	-.00200	1.00051
A 7	-.00801	-.00004	1.00094	-.00100	1.00151
A 8	.01952	-.00079	1.00094	-.00150	1.00081
A 9	.04006	-.00155	1.00148	.00000	1.00191
A 10	.02704	-.00043	1.00148	-.00200	1.00071
A 11	.13169	.00114	1.00148	.00050	1.00181

ITEM (G)	CORRECTION (MG)	VOLUME (AT T) (CM3)	SYSTEMATIC ERROR (MG)	3 S.D. LIMIT (MG)	UNCERTAINTY LIMIT (MG)
5.0000	.06375	.63297	.00019	.00668	.00687
3.0000	.01669	.37725	.00011	.00422	.00434
2.0000	-.01348	.25150	.00008	.00295	.00303
1.0000	.02498	.12660	.00004	.00224	.00228
1.0000	-.07910	.12574	.00004	.00224	.00228
1.0000	-.14136	.06023	.00004	.00224	.00228

TEMPERATURE T= 21.90 C

RESTRAINT FOR FOLLOWING SERIES
RESTRAINT VECTOR 0 0 0 0 0 1
MASS CORRECTION -.14136 MG
VOLUME AT 20 C .06023 CM3
SYSTEMATIC ERROR .00004 MG
3 STANDARD DEVIATION LIMIT .00224 MG

BALANCE 7
OPERATOR 84

CALIBRATICN DESIGN 62

SUM (G)	WEIGHTS USED FOR THE LINEAR COMBINATICNS GRAMS					
	5	3	2	1	1	1
6	+			+		

VALUES AND UNCERTAINTIES FOR COMBINATICNS OF WEIGHTS (UNCERTAINTY IS 3 STANDARD DEVIATICN LIMIT PLUS ALLOWANCE FOR SYSTEMATIC ERROR.)

SUM (G)	CORR (MG)	SYSTEMATIC (MG)	3 S.D. ERROR (MG)	UNCERTAINTY LIMIT (MG)
6	.08873	.00023	.00818	.00841

X Y Z CORPORATION
SOMEWHERE, U.S.A.
SET OF MASS STANDARDS : 5KG - 100MG
TEST NUMBER 654321

BALANCE 7
OPERATOR 84
MAXIMUM LOAD 6.0000 G
STARTING RESTRAINT NUMBER 80

CALIBRATION DESIGN 62

PRECISION CONTROL

OBSERVED STANDARD DEVIATION OF THE PROCESS .00131 MG
ACCEPTED STANDARD DEVIATION OF THE PROCESS .00170 MG
DEGREES OF FREEDOM 6
F RATIO .591

F RATIO IS LESS THAN 2.81 (CRITICAL VALUE FOR PROBABILITY = .01).
THEREFORE THE STANDARD DEVIATION IS IN CONTROL.

CHECK STANDARD VECTOR 0 0 0 0 1 0
CHECK STANDARD USED 8
ACCEPTED MASS CORRECTION OF CHECK STANDARD -.07920 MG
OBSERVED CORRECTION OF CHECK STANDARD -.07910 MG
STANDARD DEVIATION OF THE OBSERVED CORRECTION .00075 MG
T VALUE .14

ABSOLUTE VALUE OF T IS LESS THAN 3.
THEREFORE CHECK STANDARD IS IN CONTROL.

TEST CONDITIONS	BEFORE	AFTER	AVERAGE
CORRECTED TEMPERATURE IN DEGREES C	21.92	21.88	21.90
CORRECTED PRESSURE IN MM HG	743.280	742.820	743.050
CORRECTED HUMIDITY IN PERCENT	35.00	35.00	35.00
COMPUTED AIR DENSITY IN MG/CM3	1.1666	1.1660	1.1663
TEMPERATURE CORRECTION	.000	.000	
PRESSURE CORRECTION	.000	.000	
HUMIDITY CORRECTION	.00	.00	
OBSERVED TEMPERATURE IN DEGREES C	21.92	21.88	
OBSERVED PRESSURE IN MM HG	743.280	742.820	
OBSERVED HUMIDITY IN PERCENT	35.00	35.00	

BALANCE 7
OPERATOR 84
ACCEPTED WITHIN STANDARD DEVIATION OF THE PROCESS .00050 MG
ACCEPTED BETWEEN STANDARD DEVIATION OF THE PROCESS .00000 MG

CALIBRATION DESIGN 62
RESTRAINT VECTOR 1 1 1 0 0 0
MASS CORRECTION OF RESTRAINT -.14136 MG
VOLUME OF WEIGHTS BEING USED IN RESTRAINT AT 22.60 C .06024 CM3
SYSTEMATIC ERROR IN THE RESTRAINT .00004 MG
3 STANDARD DEVIATION LIMIT FOR RANDOM ERROR AFFECTING RESTRAINT .00224 MG

CHECK STANDARD USED 8
CHECK STANDARD VECTOR 0 0 0 0 1 0
ACCEPTED MASS CORRECTION OF CHECK STANDARD -.02628 MG
REPORT VECTOR 1 1 1 1 0 0

TEST CONDITIONS	BEFORE	AFTER	AVERAGE
CORRECTED TEMPERATURE IN DEGREES C	22.21	22.99	22.60
CORRECTED PRESSURE IN MM HG	742.520	741.860	742.190
CORRECTED HUMIDITY IN PERCENT	36.00	35.00	35.50
COMPUTED AIR DENSITY IN MG/CM3	1.1640	1.1599	1.1620
TEMPERATURE CORRECTION	.000	.000	
PRESSURE CORRECTION	.000	.000	
HUMIDITY CORRECTION	.00	.00	
OBSERVED TEMPERATURE IN DEGREES C	22.21	22.99	
OBSERVED PRESSURE IN MM HG	742.520	741.860	
OBSERVED HUMIDITY IN PERCENT	36.00	35.00	

WEIGHTS BEING TESTED	NOMINAL VALUE G	DENSITY G/CM3 AT 20C	COEFFICIENT OF EXPANSION	ACCEPTED CORRECTION MG
500MG	.5000	16.6000	.000020	
300MG	.3000	16.6000	.000020	
200MG	.2000	16.6000	.000020	
100MG	.1000	16.6000	.000020	
S 100MG	.1000	16.6000	.000020	-.02628
SUM 100MG	.1000	8.1788	.000049	

BALANCE 7
OPERATOR 84

CALIBRATICN DESIGN 62

	MG 500	300	200	100	100	100
A 1	+	-	-	+	-	
A 2	+	-	-		+	-
A 3	+	-	-	-		+
A 4	+	-	-			
A 5	+		-	-	-	-
A 6		+	-	+	-	-
A 7		+	-	-	+	-
A 8		+	-	-	-	+
A 9			+	-	-	
A 10			+	-		-
A 11			+		-	-
R	+	+	+			

OBSERVATICNS IN DIVISICNS
DOUBLE SUBSTITUTION CNE PAN EALANCE

A 1	296.4000	224.0000	726.2000	801.2000
A 2	285.5000	240.3000	741.3000	788.9000
A 3	300.5000	241.6000	744.1000	803.7000
A 4	312.9000	253.5000	754.8000	815.5000
A 5	312.7000	239.8000	741.C000	815.60C0
A 6	303.8000	250.5000	751.5000	805.7000
A 7	290.2000	264.6C00	765.4000	791.7000
A 8	303.6000	252.3000	753.6000	806.0000
A 9	276.7000	302.60C0	804.1000	779.3000
A 10	276.7000	315.5000	817.1000	779.2000
A 11	276.6000	301.C000	802.6000	778.6000

BALANCE 7
OPERATOR 84

CALIBRATION DESIGN 62

SENSITIVITY WEIGHT
MASS .50156 MG
VOLUME .00186 CM3 AT 20 C
COEFFICIENT OF EXPANSION .000069
S*=S-PV(S)= .49940 MG

	A(I) (MG)	DELTA(I) (MG)	AVERAGE SENSITIVITY (MG/DIV)	DRIFT(I) (MG)	OBSERVED SENSITIVITY (MG/DIV)
A 1	.07347	-.00002	.00100	.00130	.00100
A 2	.04626	-.00026	.00100	.00120	.00100
A 3	.05907	.00029	.00100	.00035	.00099
A 4	.05992	.00032	.00100	.00065	.00100
A 5	.07359	-.00033	.00100	.00085	.00100
A 6	.05362	.00018	.00100	.00045	.00100
A 7	.02589	.00024	.00100	.00035	.00100
A 8	.05173	-.00008	.00100	.00055	.00100
A 9	-.02526	-.00004	.00100	.00055	.00100
A 10	-.03821	.00009	.00100	.00045	.00100
A 11	-.02411	.00029	.00100	.00020	.00100

ITEM (G)	CORRECTION (MG)	VOLUME (AT T) (CM3)	SYSTEMATIC ERROR (MG)	3 S.D. LIMIT (MG)	UNCERTAINTY LIMIT (MG)
.5000	-.04088	.03012	.00002	.00117	.00119
.3000	-.03697	.01807	.00001	.00081	.00082
.2000	-.06351	.01204	.00001	.00060	.00060
.1000	-.01219	.00602	.00000	.00058	.00058
.1000	-.02609	.00602	.00000	.00058	.00058
.1000	-.00580	.01223	.00000	.00058	.00058

TEMPERATURE T= 22.60 C

X Y Z CCRPCRATION
SOMEWHERE, U.S.A.
SET OF MASS STANDARDS : 5KG - 100MG
TEST NUMBER 654321

BALANCE 7
OPERATOR 84
MAXIMUM LCAD .6000 G
STARTING RESTRAINT NUMBER 80

CALIBRATICN DESIGN 62

PRECISION CCNTRCL

OBSERVED STANDARD DEVIATION OF THE PROCESS .00030 MG
ACCEPTED STANDARD DEVIATICN CF THE PROCESS .00050 MG
DEGREES CF FREEDOM 6
F RATIO .370

F RATIO IS LESS THAN 2.81 (CRITICAL VALUE FOR PROBABILITY = .01).
THEREFORE THE STANDARD DEVIATICN IS IN CONTROL.

CHECK STANDARD VECTOR 0 0 0 0 1 0
CHECK STANDARD USED 8
ACCEPTED MASS CORRECTION OF CHECK STANDARD -.02628 MG
OBSERVED CORRECTICN CF CHECK STANDARD -.02609 MG
STANDARD DEVIATION OF THE OBSERVED CORRECTION .00019 MG
T VALUE .97

ABSCLUTE VALUE OF T IS LESS THAN 3.
THEREFORE CHECK STANDARD IS IN CCNTROL.

TEST CONDITICNS	BEFORE	AFTER	AVERAGE
CORRECTED TEMPERATURE IN DEGREES C	22.21	22.99	22.60
CORRECTED PRESSURE IN MM HG	742.520	741.860	742.190
CORRECTED HUMIDITY IN PERCENT	36.00	35.00	35.50
COMPUTED AIR DENSITY IN MG/CM3	1.1640	1.1595	1.1620
TEMPERATURE CORRECTICN	.000	.000	
PRESSURE CORRECTION	.000	.000	
HUMIDITY CORRECTICN	.00	.00	
OBSERVED TEMPERATURE IN DEGREES C	22.21	22.99	
OBSERVED PRESSURE IN MM HG	742.520	741.860	
OBSERVED HUMIDITY IN PERCENT	36.00	35.00	

SUMMARY

FOR CONVENIENCE, THE RESULTS OF THIS WORK ARE SUMMARIZED IN TABLES I AND II. THE VALUES ASSIGNED ARE WITH REFERENCE TO THE STANDARDS IDENTIFIED ON THE DATA SHEETS. THE UNCERTAINTY FIGURE IS AN EXPRESSION OF THE OVERALL UNCERTAINTY USING THREE STANDARD DEVIATIONS AS A LIMIT TO THE EFFECT OF RANDOM ERRORS OF THE MEASUREMENT ASSOCIATED WITH THE MEASUREMENT PROCESSES. THE MAGNITUDE OF SYSTEMATIC ERRORS FROM SOURCES OTHER THAN THE USE OF ACCEPTED VALUES FOR CERTAIN STARTING STANDARDS ARE CONSIDERED NEGLIGIBLE. IT SHOULD BE NOTED THAT THE MAGNITUDE OF THE UNCERTAINTY REFLECTS THE PERFORMANCE OF THE MEASUREMENT PROCESS USED TO ESTABLISH THESE VALUES. THE MASS UNIT, AS REALIZABLE IN ANOTHER MEASUREMENT PROCESS, WILL BE UNCERTAIN BY AN AMOUNT WHICH IS A COMBINATION OF THE UNCERTAINTY OF THIS PROCESS AND THE PROCESS IN WHICH THESE STANDARDS ARE USED.

THE ESTIMATED MASS VALUES LISTED IN TABLE I ARE BASED ON AN EXPLICIT TREATMENT OF DISPLACEMENT VOLUMES, E.G., 'TRUE MASS', 'MASS IN VACUO', MASS IN THE NEWTONIAN SENSE. THE DISPLACEMENT VOLUME ASSOCIATED WITH EACH VALUE IS LISTED AS WELL AS THE VOLUMETRIC COEFFICIENT OF EXPANSION. THESE VALUES SHOULD BE USED, TOGETHER WITH APPROPRIATE CORRECTION FOR THE BUOYANT EFFECTS OF THE ENVIRONMENT, TO ESTABLISH CONSISTENT MASS VALUES FOR OBJECTS WHICH DIFFER SIGNIFICANTLY IN DENSITY AND/OR FOR MEASUREMENTS WHICH MUST BE MADE IN DIFFERING ENVIRONMENTS. THE RELATION 1LB AVDP=.45359237KG IS USED AS REQUIRED.

THE ESTIMATED MASS VALUES LISTED IN TABLE II ARE BASED ON AN IMPLICIT TREATMENT OF DISPLACEMENT VOLUMES, E.G., 'APPARENT MASS', 'APPARENT MASS VERSUS BRASS', 'APPARENT MASS VERSUS DENSITY 8.0'. THE VALUES ARE LISTED AS CORRECTIONS TO BE APPLIED TO THE LISTED NOMINAL VALUE (A POSITIVE CORRECTION INDICATES THAT THE MASS IS LARGER THAN THE STATED NOMINAL VALUE BY THE AMOUNT OF THE CORRECTION). THESE VALUES ARE COMPUTED FROM THE VALUES BASED ON AN EXPLICIT TREATMENT OF DISPLACEMENT VOLUMES USING THE FOLLOWING DEFINING RELATIONS AND ARE UNCERTAIN BY THE AMOUNT SHOWN IN TABLE I.

THE ADJUSTMENT OF WEIGHTS TO MINIMIZE THE DEVIATION FROM NOMINAL ON THE BASIS OF 'NORMAL BRASS' (IN ACCORDANCE WITH CCR. A BELOW) IS WIDESPREAD IN THIS COUNTRY AND IN MANY PARTS OF THE WORLD. VALUES STATED ON EITHER BASIS ARE INTERNALLY CONSISTENT AND DEFINITE. THERE IS, HOWEVER, A SYSTEMATIC DIFFERENCE BETWEEN THE VALUES ASSIGNED ON EACH BASIS, THE VALUE ON THE BASIS OF 'DENSITY 8.0' BEING 7 MICROGRAMS/GRAM LARGER THAN THE VALUE ON THE BASIS OF NORMAL BRASS. THIS SYSTEMATIC DIFFERENCE IS CLEARLY DETECTABLE ON MANY DIRECT READING BALANCES.

CORRECTION A - 'APPARENT MASS VERSUS BRASS' OR 'WEIGHT IN AIR AGAINST BRASS' IS DETERMINED BY A HYPOTHETICAL WEIGHING OF THE WEIGHT AT 20 CELSIUS IN AIR HAVING A DENSITY OF 1.2 MG/CM3, WITH A (NORMAL BRASS) STANDARD HAVING A DENSITY OF 8.4 G/CM3 AT 0 CELSIUS WHOSE COEFFICIENT OF VOLUMETRIC EXPANSION IS 0.000054 PER DEGREE CELSIUS, AND WHOSE VALUE IS BASED

ON ITS TRUE MASS OR WEIGHT IN VACUO.

CORRECTION B - 'APPARENT MASS VERSUS DENSITY 8.0' IS DETERMINED BY A HYPOTHETICAL WEIGHING OF THE WEIGHT, IN AIR HAVING A DENSITY OF 1.2 MG/CM3, WITH A STANDARD HAVING A DENSITY OF 8.0 G/CM3 AT 20 CELSIUS, AND WHOSE VALUE IS BASED ON ITS TRUE MASS OR WEIGHT IN VACUO.

TABLE 1

ITEM	MASS (G)	UNCERTAINTY (G)	VOL AT 20 (CM3)	COEF OF EXP
5KG	5000.06307702	.00564493	628.70150	.000045
3KG	3000.02401883	.00368509	377.21916	.000045
2KG	2000.03017279	.00268395	253.16838	.000045
1KG	1000.00660911	.00008944	125.73955	.000045
500G	500.00589889	.00005133	63.29189	.000045
300G	300.00175036	.00004085	37.72183	.000045
200G	200.00140395	.00003203	25.14792	.000045
100G	100.00101957	.00003407	12.65836	.000045
50G	50.00212579	.00001921	6.28720	.000045
30G	30.00053569	.00001521	3.77223	.000045
20G	20.00016831	.00001202	2.53167	.000045
10G	10.00011825	.00001352	1.25740	.000045
5G	5.00006375	.00000687	.63292	.000045
3G	3.00001669	.00000434	.37722	.000045
2G	1.99998652	.00000303	.25148	.000045
1G	1.00002498	.00000228	.12659	.000045
500MG	.49995912	.00000119	.03012	.000020
300MG	.29996303	.00000082	.01807	.000020
200MG	.19993649	.00000060	.01204	.000020
100MG	.09998781	.00000058	.00602	.000020

ITEM	COR.A (MG)	COR.B (MG)
5KG	23.69575	58.64401
3KG	.39018	21.35904
2KG	12.39537	26.37469
1KG	-1.26710	5.72251
500G	1.45455	4.94937
300G	-.61250	1.48438
200G	-.17129	1.22664
100G	.13071	.82967
50G	1.73196	2.08145
30G	.29940	.50909
20G	-.00946	.13033
10G	.03948	.10938
5G	.01930	.05425
3G	-.00694	.01403
2G	-.02924	-.01526
1G	.01609	.02308
500MG	-.00552	-.00202
300MG	-.01575	-.01366
200MG	-.04937	-.04797
100MG	-.00512	-.00442

APPENDIX A.3--SAMPLE PROCESS CONTROL OUTPUT

SEE SECTION 3.3 FOR A DESCRIPTION OF THIS DATA OUTPUT.

```
5247980  2     .50497   1  2.09386 4 5322.10   .24733.88   .4041.0000   .01.150384S
5237980  2    -.59562   3   .02282 3 4121.91   .01736.81  -.1040.0000   .01.155884S
5237980  4     .98400   3   .02284 6 6221.94   .04736.75  -.3440.0000   .01.155684S
5177980  6     .07388   5   .01091 6 6221.97  -.03746.30  -.6031.0000   .01.171684S
5187980  8    -.07910   7   .00131 6 6221.90  -.04743.05  -.4635.0000   .01.166384S
5187980  8    -.02609   7   .00030 6 6222.60   .78742.19  -.6635.5000-1.01.162084S
```

APPENDIX B--LISTING OF COMPUTER PROGRAM

```
--- BLKDAT SUBPROGRAM ---
      BLOCK DATA                                                        BLD00010
C*************************************************************************BLD00020
C**   ZERMAC IS MACHINE ZERO THUS THE QUANTITY NEEDS TO BE CHANGED     **BLD00030
C**   FOR DIFFERENT COMPUTERS                                          **BLD00040
C**   THIS VALUE IS USED BY SUBPROGRAM SPINV                           **BLD00050
C*************************************************************************BLD00060
      COMMON /INVCST/ ZERMAC                                            BLD00070
C*************************************************************************BLD00080
C**   KFD(I),I=1,14 CONTAINS THE DIGITS 0-9 AND CHARACTERS  -,* USED   **BLD00090
C**   BY SUBPROGRAM DPFD                                               **BLD00100
C**   WILL NEED TO CHANGE TO COMPLY WITH PROPOSED NEW FORTRAN STANDARD**BLD00110
C*************************************************************************BLD00120
      COMMON /DPFDVL/ KFD(18)                                           BLD00130
C*************************************************************************BLD00140
C**   INPUT-OUTPUT CONTROL PARAMETERS                                  **BLD00150
C**   IR IS THE CARD READER UNIT                                       **BLD00160
C**   IW IS THE LINE PRINTER UNIT                                      **BLD00170
C**   IP IS THE CARD PUNCH UNIT                                        **BLD00180
C**   IPL IS THE NUMBER OF LINES PER PRINTED PAGE                      **BLD00190
C*************************************************************************BLD00200
      COMMON /UNITIO/ IR,IW,IP,IPL,ITMP                                 BLD00210
C*************************************************************************BLD00220
C**   CHARACTERS S T C P TO DETERMINE END OF RUN                       **BLD00230
C*************************************************************************BLD00240
      COMMON /STOP/ FS,FT,FO,FP,FB                                      BLD00250
C*************************************************************************BLD00260
C**   ITEND IS THE NUMBER OF ITERATIONS ALLOWED IN COMPUTING OBSERVED  **BLD00270
C**   CORRECTION TO WEIGHT                                             **BLD00280
C**   IT IS USED IN THE MAIN PROGRAM                                   **BLD00290
C*************************************************************************BLD00300
      COMMON /ITSTOP/ ITEND                                             BLD00310
      DATA ZERMAC /1.E-8/                                               BLD00320
      DATA KFD(1),KFD(2),KFD(3),KFD(4),KFD(5),KFD(6),KFD(7),KFD(8) /1H0,BLD00330
     2 1H1,1H2,1H3,1H4,1H5,1H6,1H7/                                     BLD00340
      DATA KFD(9),KFD(10),KFD(11),KFD(12),KFD(13),KFD(14),KFD(15) /1H8, BLD00350
     2 1H9,1H ,1H-,1H.,1H*,1H+/                                         BLD00360
      DATA KFD(16),KFD(17),KFD(18) /1H,,1HD,1HE/                        BLD00370
      DATA IR,IW,IP,IPL,ITMP /5,6,1,58,7/                               BLD00380
      DATA FS,FT,FO,FP,FE /1HS,1HT,1HO,1HP,1H /                         BLD00390
      DATA ITEND /10/                                                   BLD00400
      END                                                               BLD00410
--- MAIN PROGRAM ---
C*************************************************************************MAN00010
C**   MAIN ROUTINE OF NATIONAL BUREAU OF STANDARDS MASS CALIBRATION    **MAN00020
C**   PROGRAM  VERSION OF SEPT. 10,1971                                **MAN00030
C**   WRITTEN BY ROBERT C. RAYBOLD , OFFICE OF MEASUREMENT SERVICES    **MAN00040
C**   AND MRS.R.N.VARNER , STATISTICAL ENGINEERING LABORATORY          **MAN00050
C**   NATIONAL BUREAU OF STANDARDS , WASHINGTON, D.C. 20234            **MAN00060
C**   MODIFIED BY R. N. VARNER SEPT 1979                               **MAN00070
C**                                                                    **MAN00080
C**   THE MASS CALIBRATION PROGRAM CONTAINS ONE MAIN PROGRAM           **MAN00090
C**        AND 23 SUBPROGRAMS                                          **MAN00100
```

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C**                                                                    **MAN00110
C**    PROGRAM NAME     NUMBER OF LINES OF CODE                        **MAN00120
C**                                                                    **MAN00130
C**    MAIN              628                                          **MAN00140
C**    BLKDAT             41                                          **MAN00145
C**    READ1             120                                          **MAN00150
C**    READIT            356                                          **MAN00160
C**    ERROR              56                                          **MAN00170
C**    PRINT1             67                                          **MAN00180
C**    TEXT1             125                                          **MAN00190
C**    TEXT2             125                                          **MAN00200
C**    TEXT3             125                                          **MAN00210
C**    TEXT4             125                                          **MAN00220
C**    TEXT5             121                                          **MAN00230
C**    TEXT6              40                                          **MAN00240
C**    READ2             325                                          **MAN00250
C**    SPINV             126                                          **MAN00260
C**    SAVMTX             22                                          **MAN00270
C**    INVCHK             69                                          **MAN00280
C**    PRINT2            670                                          **MAN00290
C**    PGCONT             53                                          **MAN00300
C**    HEADPG             36                                          **MAN00310
C**    FINPRT            181                                          **MAN00320
C**    TEXTS1            124                                          **MAN00330
C**    TEXTS2             30                                          **MAN00340
C**    DPFD               89                                          **MAN00350
C**    CHKLN              11                                          **MAN00360
C**    THIS PROGRAM CONTROLS THE FLOW OF THE INPUT,                   **MAN00370
C**    CALCULATIONS AND OUTPUT                                        **MAN00380
C*********************************************************************MAN00390
C**    DIMENSION FOR COMMON /PRT1/ VARIABLES                          **MAN00400
C*********************************************************************MAN00410
      DIMENSION B1(72),B2(72),B3(72),B4(72),B5(72),B6(72),B7(72),       MAN00420
     2 IDATE(3)                                                         MAN00430
C*********************************************************************MAN00440
C**    DIMENSION FOR COMMON /INPUT/ VARIABLES                         **MAN00450
C*********************************************************************MAN00460
      DIMENSION AIDCST(5,15),ANOM(15),DENSTY(15),COEFEX(15),ACCVAL(15), MAN00470
     2 ARSTIN(15),ACKSTD(15),IRSTOU(15),IPRNT(15),DESMAT(15,50),        MAN00480
     3 OBSERV(600),ALCOM(15,20)                                         MAN00490
C*********************************************************************MAN00500
C**    DIMENSION FOR COMMON /COMPUT/ VARIABLES                        **MAN00510
C*********************************************************************MAN00520
      DIMENSION SWTPRT(50),A(50),DELTA(50),OBSCOR(15),COMVOL(15),       MAN00530
     2 SERROR(15),TRISIG(15),TOTUN(15),DRIFT(50),ZERO(50),COMVOP(15),   MAN00540
     3 CORRSA(20),SIG3SA(20),UNCSA(20),IOTSTR(50),SERSA(20),DS1(50)     MAN00550
C*********************************************************************MAN00560
C**    DIMENSION FOR MAIN PROGRAM VARIABLES                           **MAN00570
C*********************************************************************MAN00580
      DIMENSION VOLP(15),CORRP(15),TEMP(15),D1(50),ILOAD(50),TEMP2(15), MAN00590
     2 ALCAD(50)                                                        MAN00600
C*********************************************************************MAN00610
C**    DIMENSION FOR COMMON /REPRT/ VARIABLES                         **MAN00620
C*********************************************************************MAN00630
      DIMENSION AITEM(5,50),APPMAS(50),TRMASS(50),UNCERT(50),VOLPRT(50),MAN00640
     2 CORRB(50),COEPRT(50)                                             MAN00650
C*********************************************************************MAN00660
C**    DIMENSION FOR COMMON /CHECK/ VARIABLES                         **MAN00670
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C*************************************************************************MAN00680
      DIMENSION BCHK(289),Y(578)                                          MAN00690
C*************************************************************************MAN00700
C**   LABELED COMMON                                                    **MAN00710
C*************************************************************************MAN00720
      COMMON /UNITIO/ IR,IW,IP,IPL,ITMP                                   MAN00730
      COMMON /PRT1/ B1,B2,B3,B4,B5,B6,B7,RANERR,SYSERR,TNCM,L1,L2,L3,L4,MAN00740
     2 L5,L6,IDATE,IBREST                                                 MAN00750
      COMMON /PRT2/ IPAGE,NOSER,IPGCT                                     MAN00760
      COMMON /INPUT/ TBAR,PBAR,HBAR,STDEBA,SWT,VSWT,CEXSWT,AIDCST,ANOM,  MAN00770
     2 DENSTY,COEFEX,ACCVAL,ARSTIN,ACKSTD,DESMAT,CBSERV,VARBAL,ALCOM,T1PMAN00780
     3,T2P,P1P,P2P,H1P,H2P,CP1,CP2,CT1,CT2,CH1,CH2,OT1P,OT2P,OP1P,OP2P,  MAN00790
     4 OH1P,OH2P,IOP,IBAL,NOBS,NUNKN,IRSTCU,IPRNT,ITPOS,ICKUSD,ICALDS,   MAN00800
     5 LINVAR,N3,N4                                                       MAN00810
      COMMON /COMPUT/ OBSCOR,CORR,VOLRES,RHOA,SWTPRT,A,DELTA,CCMVOL,     MAN00820
     2 SERROR,TRISIG,TCTUN,ACCRR,CORRES,TMSUM,VOLSUM,SERSUM,T3SIG,ALOADPMAN00830
     3,OBSTD,FRATIO,OBCCCK,OBSCK,TVAL,DRIFT,ZERO,V2TAU,STAR,CCMVOP,      MAN00840
     4 CORR5A,SIG35A,UNC5A,RHOAA,RHOAB,SER5A,DS1,NDGFR,ISWTCH,IFLAG,     MAN00850
     5 IRCUT,IOTSTR,JSTAR                                                 MAN00860
      COMMON /REPRT/ TRMASS,APPMAS,CORRB,AITEM,UNCERT,VOLPRT,CCEPRT,NPRTMAN00870
      COMMON /CHECK/ CHCKMA,BCHK,Y                                        MAN00880
      COMMON /ITSTOP/ ITEND                                               MAN00890
      COMMON /DPFDVL/ KFC(18)                                             MAN00900
C*************************************************************************MAN00910
C**   TYPE STATEMENTS                                                   **MAN00920
C*************************************************************************MAN00930
      DOUBLE PRECISION VOLP,CORRP,OBSCOR,TRMASS,APPMAP,APPMAS,CORRBB,    MAN00940
     2 CORRB,SUM,SUM1                                                     MAN00950
C*************************************************************************MAN00960
C**   READ IN ADMINISTRATIVE DATA                                       **MAN00970
C**           DATA COMMON TO ALL SERIES                                 **MAN00980
C**   INITIALIZE CONTROL VARIABLES                                      **MAN00990
C*************************************************************************MAN01000
10    CALL READ1                                                          MAN01010
      NXFLAG=0                                                            MAN01020
      NXNSIG=0                                                            MAN01030
      IPAGE=0                                                             MAN01040
      NPRT=0                                                              MAN01050
      NOSER=0                                                             MAN01060
      ASSIGN 40 TO NCSERP                                                 MAN01070
      ASSIGN 410 TO NSERPP                                                MAN01080
C*************************************************************************MAN01090
C**   PRINT TITLE PAGE FOR COMPLETE RUN                                 **MAN01100
C*************************************************************************MAN01110
      CALL PRINT1                                                         MAN01120
C*************************************************************************MAN01130
C**   READ DATA FOR ONE SERIES                                          **MAN01140
C*************************************************************************MAN01150
20    CALL READ2                                                          MAN01160
C*************************************************************************MAN01170
C**   SET UP CHCKMA=STDEEA/100.0   TO CHECK MATRIX INVERSION            **MAN01180
C*************************************************************************MAN01190
      CHCKMA=STDEBA/100.0                                                 MAN01200
C*************************************************************************MAN01210
C**   BEGIN CALCULATIONS FOR ONE SERIES                                 **MAN01220
C**   CALCULATIONS FOR FIRST PRINTED PAGE OF A SERIES                   **MAN01230
C*************************************************************************MAN01240
      JSTAR=0                                                             MAN01250
```

```
      TDELT=TBAR-TNOM                                                    MAN01260
      DO 30 I=1,NUNKN                                                    MAN01270
30    TEMP2(I)=1.0+COEFEX(I)*TDELT                                       MAN01280
      GO TO NCSERR, (40,60)                                              MAN01290
40    ASSIGN 60 TO NCSERR                                                MAN01300
      CORR=0.0                                                           MAN01310
      VOLRES=0.0                                                         MAN01320
      DO 50 I=1,NUNKN                                                    MAN01330
      TEMP(I)=((ANOM(I)+.001*ACCVAL(I))/DENSTY(I))*TEMP2(I)              MAN01340
      IF (ARSTIN(I).EQ.0.0) GO TO 50                                     MAN01350
      CORR=CORR+ACCVAL(I)*ARSTIN(I)                                      MAN01360
      VOLRES=VOLRES+TEMP(I)*ARSTIN(I)                                    MAN01370
50    CONTINUE                                                           MAN01380
      GO TO 70                                                           MAN01390
60    CORR=TMSUM                                                         MAN01400
      VOLRES=VOLSUM*(1.0+(SUMP)*TDELT)                                   MAN01410
C*****************************************************************MAN01420
C**   CONVERT TEMPERATURE TO KELVIN                                 **MAN01430
C**   COMPUTE VAPOR PRESSURE AND AIR DENSITY                        **MAN01440
C*****************************************************************MAN01450
70    TKEL=TEAR+273.15E0                                                 MAN01460
      CONST=13.5951E0*9.80665E0                                          MAN01470
      E1P=EXP(-4.7406885E0*ALOG(TKEL)-6.8982434E3/TKEL+.5938385E2-0.5797MAN01480
     2662E-2*TKEL+6.2223854E-6*(TKEL**2))                                MAN01490
      E1=E1P/CONST                                                       MAN01500
      RHOA=(.464746E0*(PEAR-.0037802SE0*HEAR*E1))/TKEL                   MAN01510
      TKEL=T1P+273.15E0                                                  MAN01520
      E1P=EXP(-4.7406885E0*ALOG(TKEL)-6.8982434E3/TKEL+.5938385E2-0.5797MAN01530
     2662E-2*TKEL+6.2223854E-6*(TKEL**2))                                MAN01540
      E1=E1P/CONST                                                       MAN01550
      RHOAB=(.464746E0*(P1P-.0037802SE0*H1P*E1))/TKEL                    MAN01560
      TKEL=T2P+273.15E0                                                  MAN01570
      E1P=EXP(-4.7406885E0*ALOG(TKEL)-6.8982434E3/TKEL+.5938385E2-0.5797MAN01580
     2662E-2*TKEL+6.2223854E-6*(TKEL**2))                                MAN01590
      E1=E1P/CONST                                                       MAN01600
      RHOAA=(.464746E0*(P2P-.0037802SE0*H2P*E1))/TKEL                    MAN01610
C*****************************************************************MAN01620
C**   BEGIN CALCULATIONS FOR SECOND AND THIRD PAGES OF A SERIES     **MAN01630
C**   THE FOLLOWING OPERATIONS ARE PERFORMED TO COPE WITH           **MAN01640
C**   ROUND OFF ERROR                                               **MAN01650
C**   COMPUTE LOADS USING DESIGN MATRIX                             **MAN01660
C*****************************************************************MAN01670
      DO 130 I=1,NOBS                                                    MAN01680
      ILOAD(I)=0                                                         MAN01690
      YYYYYY=0.0                                                         MAN01700
      DO 80 J=1,NUNKN                                                    MAN01710
      YYYYYY=YYYYYY+ABS(DESMAT(J,I))*ANOM(J)/2.0                         MAN01720
80    CONTINUE                                                           MAN01730
      ZZZZZZ=YYYYYY+.05                                                  MAN01740
      IF (ZZZZZZ-1.) 100,90,90                                           MAN01750
C*****************************************************************MAN01760
C**   LOAD IN GRAMS                                                 **MAN01770
C*****************************************************************MAN01780
90    ILOAD(I)=INT(YYYYYY+.05)                                           MAN01790
      GO TO 130                                                          MAN01800
C*****************************************************************MAN01810
C**   LOAD IN MILLIGRAMS OR MILLIPOUNDS                             **MAN01820
C*****************************************************************MAN01830
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100   ZZZZZZ=YYYYYY*1000.+.05                                          MAN01840
      IF (ZZZZZZ-1.) 120,110,110                                       MAN01850
110   ILOAD(I)=INT(1000.000*YYYYYY+.05)                                MAN01860
      GO TO 130                                                        MAN01870
C*****************************************************************MAN01880
C**   LOAD IN MICRO POUNDS                                          **MAN01890
C*****************************************************************MAN01900
120   ILOAD(I)=INT(1000000.*YYYYYY+.05)                                MAN01910
130   CONTINUE                                                         MAN01920
      ALOADP=0.0                                                       MAN01930
      DO 160 I=1,NOBS                                                  MAN01940
      ALOAD(I)=0.0                                                     MAN01950
      DO 140 J=1,NUNKN                                                 MAN01960
      ALOAD(I)=ALOAD(I)+ABS(DESMAT(J,I))*ANOM(J)/2.0                   MAN01970
140   CONTINUE                                                         MAN01980
      IF (ALOADP-ALOAD(I)) 150,160,160                                 MAN01990
150   ALOADP=ALOAD(I)                                                  MAN02000
160   CONTINUE                                                         MAN02010
C*****************************************************************MAN02020
C**   COMPUTE S(STAR) SENSITIVITY VALUE (MASS/DIVISION)             **MAN02030
C**   COMPUTE S(*) SENSITIVITY VALUE (MASS/DIVISION)                **MAN02040
C**   COMPUTE A-B , S , DRIFT AND/OR LEFT-RIGHT EFFECT AS REQUIRED BY **MAN02050
C**   WEIGHING METHOD                                               **MAN02060
C*****************************************************************MAN02070
      STAR=SWT-RHOA*VSWT*(1.0+CEXSWT*(TDELT))                          MAN02080
      J=1                                                              MAN02090
      DO 290 I=1,NOBS                                                  MAN02100
      GO TO (170,200,230,260,270,  280), ITPOS                         MAN02110
C*****************************************************************MAN02120
C**   SINGLE SUBSTITUTION-SINGLE PAN BALANCE                        **MAN02130
C*****************************************************************MAN02140
170   D1(I)=OBSERV(J)-OBSERV(J+1)                                      MAN02150
      IF (OBSERV(J+2).NE.0.0) GO TO 180                                MAN02160
      DS1(I)=0.0                                                       MAN02170
      GO TO 190                                                        MAN02180
180   DS1(I)=OBSERV(J+2)-OBSERV(J+1)                                   MAN02190
190   J=J+3                                                            MAN02200
      GO TO 290                                                        MAN02210
C*****************************************************************MAN02220
C**   SINGLE SUBSTITUTION-TWO-PAN BALANCE                           **MAN02230
C*****************************************************************MAN02240
200   XP=(OBSERV(J)+2.0*OBSERV(J+1)+OBSERV(J+2))/4.0                   MAN02250
      YP=(OBSERV(J+3)+2.0*OBSERV(J+4)+OBSERV(J+5))/4.0                 MAN02260
      ZP=(OBSERV(J+6)+2.0*OBSERV(J+7)+OBSERV(J+8))/4.0                 MAN02270
      D1(I)=XP-YP                                                      MAN02280
      IF (ZP.NE.0.0) GO TO 210                                         MAN02290
      DS1(I)=0.0                                                       MAN02300
      GO TO 220                                                        MAN02310
210   DS1(I)=ABS(ZP-YP)                                                MAN02320
220   J=J+9                                                            MAN02330
      GO TO 290                                                        MAN02340
C*****************************************************************MAN02350
C**   SINGLE TRANSPOSITION-TWO-PAN BALANCE                          **MAN02360
C*****************************************************************MAN02370
230   XP=(OBSERV(J)+2.0*OBSERV(J+1)+OBSERV(J+2))/4.0                   MAN02380
      YP=(OBSERV(J+3)+2.0*OBSERV(J+4)+OBSERV(J+5))/4.0                 MAN02390
      ZP=(OBSERV(J+6)+2.0*OBSERV(J+7)+OBSERV(J+8))/4.0                 MAN02400
      D1(I)=(XP-YP)/2.0                                                MAN02410
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      ZERO(I)=(XP+YP)/2.0                                                MAN02420
      IF (ZP.NE.0.0) GO TO 240                                           MAN02430
      DS1(I)=0.0                                                         MAN02440
      GO TO 250                                                          MAN02450
240   DS1(I)=ABS(ZP-YP)                                                  MAN02460
250   J=J+9                                                              MAN02470
      GO TO 290                                                          MAN02480
C*****************************************************************MAN02490
C**   DOUBLE SUBSTITUTION-ONE PAN BALANCE                          **MAN02500
C*****************************************************************MAN02510
260   D1(I)=(OBSERV(J)-OBSERV(J+1)-OBSERV(J+2)+OBSERV(J+3))/2.0          MAN02520
      DS1(I)=(OBSERV(J)-3.0*OBSERV(J+1)+3.0*OBSERV(J+2)-OBSERV(J+3))/2.0MAN02530
      DRIFT(I)=(-OBSERV(J)+OBSERV(J+1)-OBSERV(J+2)+OBSERV(J+3))/2.0      MAN02540
      J=J+4                                                              MAN02550
      GO TO 290                                                          MAN02560
C*****************************************************************MAN02570
C**   DOUBLE SUBSTITUTION-TWO PAN BALANCE                          **MAN02580
C*****************************************************************MAN02590
270   XP=(OBSERV(J)+2.0*OBSERV(J+1)+OBSERV(J+2))/4.0                     MAN02600
      YP=(OBSERV(J+3)+2.0*OBSERV(J+4)+OBSERV(J+5))/4.0                   MAN02610
      ZP=(OBSERV(J+6)+2.0*OBSERV(J+7)+OBSERV(J+8))/4.0                   MAN02620
      WP=(OBSERV(J+9)+2.0*OBSERV(J+10)+OBSERV(J+11))/4.0                 MAN02630
      D1(I)=(XP-YP-ZP+WP)/2.0                                            MAN02640
      DS1(I)=ABS((XP-3.*YP+3.*ZP-WP)/2.0)                                MAN02650
      DRIFT(I)=(-XP+YP-ZP+WP)/2.0                                        MAN02660
      J=J+12                                                             MAN02670
      GO TO 290                                                          MAN02680
C*****************************************************************MAN02690
C**   DOUBLE TRANSPOSITION-TWO PAN BALANCE                         **MAN02700
C*****************************************************************MAN02710
280   XP=(OBSERV(J)+2.0*OBSERV(J+1)+OBSERV(J+2))/4.0                     MAN02720
      YP=(OBSERV(J+3)+2.0*OBSERV(J+4)+OBSERV(J+5))/4.0                   MAN02730
      ZP=(OBSERV(J+6)+2.0*OBSERV(J+7)+OBSERV(J+8))/4.0                   MAN02740
      WP=(OBSERV(J+9)+2.0*OBSERV(J+10)+OBSERV(J+11))/4.0                 MAN02750
      D1(I)=(XP-YP-ZP+WP)/4.0                                            MAN02760
      DS1(I)=ABS((XP-3.*YP+3.*ZP-WP)/2.0)                                MAN02770
      ZERO(I)=(3.0*XP+YP+ZP-WP)/4.0                                      MAN02780
      DRIFT(I)=(-XP+YP-ZP+WP)/2.0                                        MAN02790
      J=J+12                                                             MAN02800
290   CONTINUE                                                           MAN02810
C*****************************************************************MAN02820
C**   COMPUTE  S(*)/D(S),A(I),DRIFT(I),ZERO(I)                     **MAN02830
C*****************************************************************MAN02840
      KA=1                                                               MAN02850
      SUM=0.0                                                            MAN02860
      J=0                                                                MAN02870
      I=1                                                                MAN02880
      ILOOPP=ILOAD(I)                                                    MAN02890
C*****************************************************************MAN02900
C**   CHECK FOR LOAD CHANGES                                       **MAN02910
C*****************************************************************MAN02920
300   IF (ILOAD(I).NE.ILOOPP) GO TO 320                                  MAN02930
      IF (DS1(I).EQ.0.0) GO TO 310                                       MAN02940
      SUM=SUM+DS1(I)                                                     MAN02950
      DS1(I)=STAR/DS1(I)                                                 MAN02960
      J=J+1                                                              MAN02970
310   I=I+1                                                              MAN02980
      IF (I.GT.NOBS) GO TO 330                                           MAN02990
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      GO TO 300                                                          MAN03000
320   ILODPP=ILOAD(I)                                                    MAN03010
330   FLTN=J                                                             MAN03020
      DBAR=SUM/FLTN                                                      MAN03030
      FLTNSQ=SQRT(FLTN)                                                  MAN03040
      DSP=STAR/DBAR                                                      MAN03050
      KB=I-1                                                             MAN03060
      DO 360 K=KA,KB                                                     MAN03070
      SWTPRT(K)=ABS(DSP)                                                 MAN03080
      A(K)=D1(K)*DSP                                                     MAN03090
      DRIFT(K)=DRIFT(K)*DSP                                              MAN03100
      IF (N4.EQ.0) GO TO 340                                             MAN03110
C*********************************************************************MAN03120
C**   CHANGE SIGN FOR REVERSED SCALE                                  **MAN03130
C*********************************************************************MAN03140
      A(K)=-1.*A(K)                                                      MAN03150
      DRIFT(K)=-1.*DRIFT(K)                                              MAN03160
340   IF (ABS(D1(K)/(DBAR*FLTNSQ)).LE.0.25) GO TO 350                    MAN03170
C*********************************************************************MAN03180
C**   IF OBSERVED DEFLECTION IS GREATER THAN OR EQUAL TO              **MAN03190
C**   .25*SENSITIVITY DEFLECTION A FLAG IS SET UP                     **MAN03200
C*********************************************************************MAN03210
      ICTSTR(K)=KFD(14)                                                  MAN03220
      JSTAR=1                                                            MAN03230
      GO TO 360                                                          MAN03240
350   ICTSTR(K)=KFD(11)                                                  MAN03250
360   CONTINUE                                                           MAN03260
      IF (I.GT.NOBS) GO TO 370                                           MAN03270
      J=0                                                                MAN03280
      SUM=0.0                                                            MAN03290
      KA=I                                                               MAN03300
      GO TO 300                                                          MAN03310
C*********************************************************************MAN03320
C**   COMPUTE DENSITY AND COEFFICIENT OF EXPANSION OF WEIGHTS         **MAN03330
C**   BEING TESTED                                                    **MAN03340
C**   COMPUTE XREST (RESTRAINT VALUE) FOR Y(M,N)                      **MAN03350
C*********************************************************************MAN03360
370   NXXSIG=0                                                           MAN03370
      DO 380 I=1,NUNKN                                                   MAN03380
      IF (ARSTIN(I).EQ.0.0) GO TO 380                                    MAN03390
      NXXSIG=NXXSIG+1                                                    MAN03400
380   CONTINUE                                                           MAN03410
      IF (NXXSIG.LT.2) GO TO 400                                         MAN03420
      IF (NXXSIG.GT.1) GO TO 400                                         MAN03430
      DO 390 I=1,NUNKN                                                   MAN03440
      IF (ARSTIN(I).EQ.0.0) GO TO 390                                    MAN03450
      DENSTY(I)=(ANOM(I)+.001*TMSUM)/VOLSUM                              MAN03460
      COEFEX(I)=SUMP                                                     MAN03470
390   CONTINUE                                                           MAN03480
400   GO TO NSERPP, (410,430)                                            MAN03490
410   ASSIGN 430 TO NSERPP                                               MAN03500
      XREST=0.0                                                          MAN03510
      TMSUM=0.0                                                          MAN03520
      DO 420 I=1,NUNKN                                                   MAN03530
      IF (ARSTIN(I).EQ.0.0) GO TO 420                                    MAN03540
      XREST=XREST+(ACCVAL(I)-RHOA*TEMP(I))*ARSTIN(I)                     MAN03550
      TMSUM=TMSUM+ACCVAL(I)*ARSTIN(I)                                    MAN03560
420   CONTINUE                                                           MAN03570
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      GO TO 440                                                          MAN03580
430   XREST=TMSUM-RHOA*VOLSUM*(1.0+SUMP*TDELT)                           MAN03590
C*****************************************************************MAN03600
C**   MULTIPLY TRANSPOSE OF DESIGN MATRIX BY ITSELF AND STORE IN Y    **MAN03610
C*****************************************************************MAN03620
440   L=0                                                                MAN03630
      DO 470 IA=1,NUMKN                                                  MAN03640
      DO 460 IAA=1,NUMKN                                                 MAN03650
      L=L+1                                                              MAN03660
      SUM=0.0                                                            MAN03670
      DO 450 JA=1,NOBS                                                   MAN03680
      SUM=SUM+DESMAT(IAA,JA)*DESMAT(IA,JA)                               MAN03690
450   CONTINUE                                                           MAN03700
      Y(L)=SUM                                                           MAN03710
460   CONTINUE                                                           MAN03720
      L=L+2                                                              MAN03730
      Y(L-1)=ARSTIN(IA)                                                  MAN03740
      Y(L)=0.0                                                           MAN03750
470   CONTINUE                                                           MAN03760
C*****************************************************************MAN03770
C**   SET UP REMAINING ELEMENTS OF MATRIX X                            **MAN03780
C*****************************************************************MAN03790
      IRIN=0                                                             MAN03800
      DO 480 I=1,NUMKN                                                   MAN03810
      L=L+1                                                              MAN03820
      Y(L)=ARSTIN(I)                                                     MAN03830
      IF (ARSTIN(I).EQ.0.0) GO TO 480                                    MAN03840
      IRIN=1.0                                                           MAN03850
480   CONTINUE                                                           MAN03860
      L=L+2                                                              MAN03870
      IF (IRIN.EQ.0) GO TO 490                                           MAN03880
      Y(L-1)=0.0                                                         MAN03890
      GO TO 500                                                          MAN03900
490   Y(L-1)=1.0                                                         MAN03910
500   Y(L)=0.0                                                           MAN03920
C*****************************************************************MAN03930
C**   COMPUTE X'Y                                                      **MAN03940
C*****************************************************************MAN03950
      DO 520 IAA=1,NUMKN                                                 MAN03960
      L=L+1                                                              MAN03970
      SUM=0.0                                                            MAN03980
      DO 510 JA=1,NOBS                                                   MAN03990
      SUM=SUM+DESMAT(IAA,JA)*A(JA)                                       MAN04000
510   CONTINUE                                                           MAN04010
      Y(L)=SUM                                                           MAN04020
520   CONTINUE                                                           MAN04030
      Y(L+1)=XREST                                                       MAN04040
      Y(L+2)=-1.0                                                        MAN04050
C*****************************************************************MAN04060
C**   CALL MATRIX INVERSION ROUTINE                                    **MAN04070
C*****************************************************************MAN04080
      CALL SPINV (Y,NUMKN+2,NUMKN+2,IFLAG)                               MAN04090
C*****************************************************************MAN04100
C**   IF MATRIX IS SINGULAR PRINT FIRST TWO PAGES OF SERIES AND        **MAN04110
C**   TERMINATE RUN                                                    **MAN04120
C**   IFLAG=0  INVERSE SUCCESSFUL                                      **MAN04130
C**   IFLAG=4  MATRIX SINGULAR                                         **MAN04140
C**   IFLAG=-1 I-AA(INV) FAILED                                        **MAN04150
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C*****************************************************************MAN04160
      IF (IFLAG.EQ.0) GO TO 530                                      MAN04170
      CALL PRINT2                                                    MAN04180
      STOP                                                           MAN04190
C*****************************************************************MAN04200
C**   COMPUTE DELTA(I)=A(I)-DESMAT*BETA(I)                        **MAN04210
C*****************************************************************MAN04220
530   L=(NUNKN+2)*(NUNKN+1)+1                                        MAN04230
      DO 550 I=1,NOBS                                                MAN04240
      LA=L                                                           MAN04250
      SUM=0.0                                                        MAN04260
      DO 540 J=1,NUNKN                                               MAN04270
      SUM=SUM+DESMAT(J,I)*Y(LA)                                      MAN04280
      LA=LA+1                                                        MAN04290
540   CONTINUE                                                       MAN04300
      DELTA(I)=A(I)-SUM                                              MAN04310
550   CONTINUE                                                       MAN04320
C*****************************************************************MAN04330
C**   CALCULATE CORRECTION AND VOLUME FOR THIRD OUTPUT PAGE        **MAN04340
C**   OF A SERIES                                                  **MAN04350
C*****************************************************************MAN04360
      LA=L                                                           MAN04370
      DO 560 I=1,NUNKN                                               MAN04380
      VOLP(I)=(ANOM(I)/DENSTY(I))*TEMP2(I)                           MAN04390
      CORRP(I)=Y(LA)+RHOA*VOLP(I)                                    MAN04400
      LA=LA+1                                                        MAN04410
560   CONTINUE                                                       MAN04420
C*****************************************************************MAN04430
C**   BEGIN ITERATION AND ITERATE   UNTIL DIFFERENCE BETWEEN OLD   **MAN04440
C**   AND NEW VALUES ARE LESS THAN .01 STDERA                      **MAN04450
C**   ONLY 10 ITERATIONS ARE ALLOWED                               **MAN04460
C*****************************************************************MAN04470
      CHCK=.01*STDERA                                                MAN04480
      ISTOP=0                                                        MAN04490
570   ISWTCH=0                                                       MAN04500
      LA=L                                                           MAN04510
      DO 600 I=1,NUNKN                                               MAN04520
      OBSCOR(I)=Y(LA)+RHOA*((ANOM(I)+.001*CORRP(I))/DENSTY(I))*TEMP2(I) MAN04530
      LA=LA+1                                                        MAN04540
      IF (ISWTCH.NE.0) GO TO 590                                     MAN04550
      IF (SNGL(DABS(OBSCOR(I)-CORRP(I)))-CHCK) 590,590,580           MAN04560
580   ISWTCH=1                                                       MAN04570
590   CORRP(I)=OBSCOR(I)                                             MAN04580
600   CONTINUE                                                       MAN04590
      ISTOP=ISTOP+1                                                  MAN04600
      IF (ISTOP.GE.ITEND) GO TO 610                                  MAN04610
      IF (ISWTCH.NE.0) GO TO 570                                     MAN04620
610   WR=0.0                                                         MAN04630
      DO 620 I=1,NUNKN                                               MAN04640
      IF (ARSTIN(I).EQ.0.0) GO TO 620                                MAN04650
      WR=WR+ANOM(I)*ARSTIN(I)                                        MAN04660
620   CONTINUE                                                       MAN04670
      TRSQR=RANERR**2                                                MAN04680
      TRSQRP=(3.0*STDERA)**2                                         MAN04690
      TRSQVE=(3.0*VAREAL)**2                                         MAN04700
      LA=1                                                           MAN04710
      DO 670 I=1,NUNKN                                               MAN04720
      COMVOL(I)=(ANOM(I)+.001*OBSCOR(I))/DENSTY(I)                   MAN04730
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      COMVOP(I)=COMVOL(I)*TEMP2(I)                                      MAN04740
      SERROR(I)=(ANOM(I)/WR)*SYSERR                                     MAN04750
      TRTEMP=TRSQRP*Y(LA)+((ANOM(I)/WR)**2)*TRISQR+TRSQVB               MAN04760
      IF (TRTEMP) 630,640,640                                           MAN04770
630   WRITE (IW,890) TRTEMP                                             MAN04780
      GO TO 660                                                         MAN04790
640   IF (TRTEMP.GE.0.0) GO TO 650                                      MAN04800
      TRTEMP=0.0                                                        MAN04810
650   TRISIG(I)=SQRT(TRTEMP)                                            MAN04820
660   TOTUN(I)=SERROR(I)+TRISIG(I)                                      MAN04830
      LA=LA+NUNKN+3                                                     MAN04840
670   CONTINUE                                                          MAN04850
      ACORR=TMSUM                                                       MAN04860
      CORRES=0.0                                                        MAN04870
      TMSUM=0.0                                                         MAN04880
      SERSUM=0.0                                                        MAN04890
      T3SIG=0.0                                                         MAN04900
      DO 690 I=1,NUNKN                                                  MAN04910
      IF (ARSTIN(I).EQ.0.0) GO TO 680                                   MAN04920
      CORRES=CORRES+OBSCOR(I)*ARSTIN(I)                                 MAN04930
680   IF (IRSTOU(I).EQ.0) GO TO 690                                     MAN04940
C*****************************************************************MAN04950
C**   COMPUTE MASS FOR NEXT RESTRAINT                              **MAN04960
C*****************************************************************MAN04970
      TMSUM=TMSUM+OBSCOR(I)                                             MAN04980
690   CONTINUE                                                          MAN04990
      VOLSUM=0.0                                                        MAN05000
      IROUT=0                                                           MAN05010
      NXNSIG=0                                                          MAN05020
      DO 700 I=1,NUNKN                                                  MAN05030
      IF (IRSTOU(I).EQ.0) GO TO 700                                     MAN05040
      IROUT=1                                                           MAN05050
      VOLSUM=VOLSUM+(ANOM(I)+.001*OBSCOR(I))/DENSTY(I)                  MAN05060
      NXNSIG=NXNSIG+1                                                   MAN05070
700   CONTINUE                                                          MAN05080
C*****************************************************************MAN05090
C**   CALCULATIONS FOR THIRD OUTPUT PAGE OF SERIES                 **MAN05100
C**   COMPUTE SYSTEMATIC AND RANDOM ERROR AND TOTAL UNCERTAINTY    **MAN05110
C*****************************************************************MAN05120
      LINVV=LINVAR+1                                                    MAN05130
      DO 710 K=1,NUNKN                                                  MAN05140
710   ALCOM(K,LINVV)=IRSTOU(K)                                          MAN05150
      DO 770 L=1,LINVV                                                  MAN05160
      CORRSA(L)=0.0                                                     MAN05170
      SERSA(L)=0.0                                                      MAN05180
      DO 720 K=1,NUNKN                                                  MAN05190
      CORRSA(L)=CORRSA(L)+OBSCOR(K)*ALCOM(K,L)                          MAN05200
      SERSA(L)=ABS(SERSA(L)+SERROR(K)*ALCOM(K,L))                       MAN05210
720   CONTINUE                                                          MAN05220
      LA=1                                                              MAN05230
      DO 740 I=1,NUNKN                                                  MAN05240
      TEMP(I)=0.0                                                       MAN05250
      DO 730 J=1,NUNKN                                                  MAN05260
      TEMP(I)=TEMP(I)+Y(LA)*ALCOM(J,L)                                  MAN05270
730   LA=LA+1                                                           MAN05280
740   LA=LA+2                                                           MAN05290
      SUM=0.0                                                           MAN05300
      SUM2RP=0.0                                                        MAN05310
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      DO 750 J=1,NUNKN                                                  MAN05320
      SUM2RP=SUM2RP+ANOM(J)*ALCCM(J,L)                                  MAN05330
750   SUM=SUM+TEMP(J)*ALCCM(J,L)                                        MAN05340
      IF (SUM.GE.0.0) GO TO 760                                         MAN05350
      SUM=0.0                                                           MAN05360
760   CONTINUE                                                          MAN05370
      SIG35A(L)=SQRT(TRSQRP*SUM+((SUM2RP/WR)**2)*TRISQR+TRSQVE)         MAN05380
      UNCSA(L)=SER5A(L)+SIG35A(L)                                       MAN05390
770   CONTINUE                                                          MAN05400
      SERSUM=SER5A(LINVV)                                               MAN05410
      T3SIG=SIG35A(LINVV)                                               MAN05420
C*****************************************************************************MAN05430
C**   BEGIN COMPUTATIONS FOR FOURTH PAGE -- F RATIO AND T-TEST         **MAN05440
C*****************************************************************************MAN05450
      NDGFR=NOBS-NUNKN+1                                                MAN05460
      SUM=0.0                                                           MAN05470
      DO 780 I=1,NOBS                                                   MAN05480
      SUM=SUM+DELTA(I)**2                                               MAN05490
780   CONTINUE                                                          MAN05500
      OBSTD=SQRT(SUM/FLOAT(NDGFR))                                      MAN05510
      FRATIO=OBSTD**2/STDEBA**2                                         MAN05520
      OBCOCK=0.0                                                        MAN05530
      SUM1=0.0                                                          MAN05540
      V2TAU=0.0                                                         MAN05550
      DO 790 I=1,NUNKN                                                  MAN05560
      IF (ACKSTD(I).EQ..0) GO TO 790                                    MAN05570
      OBCOCK=CBCOCK+CBSCOR(I)*ACKSTD(I)                                 MAN05580
      SUM1=SUM1+ANOM(I)*ACKSTD(I)                                       MAN05590
      V2TAU=V2TAU+ACCVAL(I)*ACKSTD(I)                                   MAN05600
790   CONTINUE                                                          MAN05610
      LA=1                                                              MAN05620
      DO 810 J=1,NUNKN                                                  MAN05630
      TEMP(J)=0.0                                                       MAN05640
      DO 800 I=1,NUNKN                                                  MAN05650
      TEMP(J)=TEMP(J)+ACKSTD(I)*Y(LA)                                   MAN05660
800   LA=LA+1                                                           MAN05670
810   LA=LA+2                                                           MAN05680
      SUM=0.0                                                           MAN05690
      DO 820 I=1,NUNKN                                                  MAN05700
820   SUM=SUM+TEMP(I)*ACKSTD(I)                                         MAN05710
      IF (SUM.GE.0.0) GO TO 830                                         MAN05720
      SUM=0.0                                                           MAN05730
830   CONTINUE                                                          MAN05740
      OBSCK=SQRT(STDEBA**2*SUM+(SUM1/WR)**2*(RANERR/3.0)**2+VAREAL**2)  MAN05750
      IF (OBSCK.NE.0.0) GO TO 840                                       MAN05760
      TVAL=0.0                                                          MAN05770
      GO TO 850                                                         MAN05780
840   TVAL=(OBCOCK-V2TAU)/OBSCK                                         MAN05790
C*****************************************************************************MAN05800
C**   SAVE VALUES FOR FINAL RERUN                                      **MAN05810
C*****************************************************************************MAN05820
850   DO 860 I=1,NUNKN                                                  MAN05830
      IF (IPRNT(I).EQ.0) GO TO 860                                      MAN05840
      NPRT=NPRT+1                                                       MAN05850
      AITEM(1,NPRT)=AIDCST(1,I)                                         MAN05860
      AITEM(2,NPRT)=AIDCST(2,I)                                         MAN05870
      AITEM(3,NPRT)=AIDCST(3,I)                                         MAN05880
      AITEM(4,NPRT)=AIDCST(4,I)                                         MAN05890
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      AITEM(5,NPRT)=AIDCST(5,I)                                          MAN05900
      APPMAP=((ANOM(I)+.001*CESCOR(I))*(1.0-.0012/DENSTY(I)))/(1.0-.0012MAN05910
     2*(1.0+.000054*20.0)/8.4)                                           MAN05920
      APPMAS(NPRT)=(APPMAP-ANOM(I))*1000.                                MAN05930
      TRMASS(NPRT)=ANOM(I)+.001*CBSCOR(I)                                MAN05940
      UNCERT(NPRT)=.001*TOTUN(I)                                         MAN05950
      VOLPRT(NPRT)=CCMVOL(I)                                             MAN05960
      CORRBB=((ANOM(I)+.001*CBSCOR(I))*(1.0-.0012/DENSTY(I)))/(1.0-.0012MAN05970
     2/8.0)                                                              MAN05980
      CORRB(NPRT)=(CORRBB-ANOM(I))*1000.                                 MAN05990
      COEPRT(NPRT)=COEFEX(I)                                             MAN06000
860   CONTINUE                                                           MAN06010
C*************************************************************************MAN06020
C**   SET UP VALUES FOR NEXT SERIES                                     **MAN06030
C**   PRINT FOUR PAGES OF OUTPUT FOR ONE SERIES                         **MAN06040
C*************************************************************************MAN06050
      CALL PRINT2                                                        MAN06060
      SYSERR=SERSUM                                                      MAN06070
      RANERR=T3SIG                                                       MAN06080
      SUM=0.0                                                            MAN06090
      SUM1=0.0                                                           MAN06100
      DO 870 I=1,NUNKN                                                   MAN06110
      IF (IRSTOU(I).EQ.0) GO TO 870                                      MAN06120
      SUM=SUM+(ANOM(I)+.001*CBSCOR(I))/DENSTY(I)                         MAN06130
      SUM1=SUM1+COEFEX(I)*((ANOM(I)+.001*CBSCOR(I))/DENSTY(I))           MAN06140
870   CONTINUE                                                           MAN06150
      IF (SUM.EQ.0.0) GO TO 880                                          MAN06160
      SUMP=SUM1/SUM                                                      MAN06170
880   CONTINUE                                                           MAN06180
      IF (IRCUT.NE.0) GO TO 20                                           MAN06190
      IF (NPRT.EQ.0) GO TO 10                                            MAN06200
      CALL FINPRT                                                        MAN06210
      GO TO 10                                                           MAN06220
C*************************************************************************MAN06230
C**   FORMAT STATEMENT                                                  **MAN06240
C*************************************************************************MAN06250
890   FORMAT (14H NEG SQRT ARG=E16.7)                                    MAN06260
      END                                                                MAN06270
--- READ1 SUBPROGRAM ---
      SUBROUTINE READ1                                                   RD100010
C*************************************************************************RD100020
C**   SUBROUTINE OF THE NATIONAL BUREAU OF STANDARDS MASS CALIBRATION    **RD100030
C**   PROGRAM  VERSION OF SEPT.10,1971     WRITTEN BY R.C.RAYBOLD        **RD100040
C**   AND MRS.R.N.VARNER                                                **RD100050
C**   MODIFIED BY R. N. VARNER SEPT 1979                                **RD100060
C*************************************************************************RD100070
C**   SUBROUTINE TO READ DATA COMMON TO ALL SERIES                       **RD100080
C*************************************************************************RD100090
C**   DIMENSION FOR COMMON /PRT1/ VARIABLES                             **RD100100
C*************************************************************************RD100110
      DIMENSION B1(72),B2(72),B3(72),B4(72),B5(72),B6(72),B7(72),        RD100120
     2 IDATE(3)                                                          RD100130
C*************************************************************************RD100140
C**   DIMENSION FOR COMMON /RAREA/ VARIABLES                            **RD100150
C*************************************************************************RD100160
      DIMENSION AA(72),AAITEM(5)                                         RD100170
C*************************************************************************RD100180
C**   LABELED COMMON                                                    **RD100190
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C*****************************************************************RD100200
      COMMCN /PRT1/ B1,B2,B3,B4,B5,B6,B7,RANERR,SYSERR,TNCM,L1,L2,L3,L4,RD100210
     2 L5,L6,IDATE,IBREST                                            RD100220
      COMMCN /RAREA/ AA,AAITEM                                       RD100230
      COMMON /UNITIO/ IR,IW,IP,IPL,ITMP                              RD100240
      COMMCN /STCP/ FS,FT,FO,FP,FB                                   RD100250
C*****************************************************************RD100260
C**   READ IN AND SET UP ADMINISTRATIVE DETAILS                   **RD100270
C**   REAC 8 CARDS  IF ALL 8 ARE NCT USED , ADD BLANK CARDS       **RD100280
C**   THESE CARDS ARE SEARCHED FOR THE 1ST NON-BLANK CHARACTER AT  **RD100290
C**   WHICH TIME ALL REMAINING CHARACTERS ARE MOVED                **RD100300
C**   TO A NEW LOCATICN STARTING IN POSITION 1                     **RD100310
C**   CARD 1 - NAME CF CRGANIZATICN                                **RD100320
C**   CARD 2 - ADDRESS   STREET NUMBER AND NAME                    **RD100330
C**   CARD 3 - ADDRESS   CITY , STATE ZIP CODE                     **RD100340
C**   CARD 4 - TYPE OF SET (EG. 1-KG TO 1-MG)                      **RD100350
C**   CARD 5 - SERIAL NUMBER OF SET CF WEIGHTS BEING TESTED        **RD100360
C**   CARD 6 - DATE OF THE REPCRT                                  **RD100370
C**   CARD 7 - TEST NUMBER (MAX OF 18 CHARACTERS)                  **RD100380
C**   EXCEPT FOR THE FIRST PRINTED PAGE CNLY THE                   **RD100390
C**   FIRST 65 CHARACTERS ARE PRINTED ON OUTPUT                    **RD100400
C*****************************************************************RD100410
      DO 10 K=1,72                                                   RD100420
      B1(K)=FB                                                       RD100430
      B2(K)=FB                                                       RD100440
      B3(K)=FB                                                       RD100450
      B4(K)=FB                                                       RD100460
      B5(K)=FB                                                       RD100470
      B6(K)=FB                                                       RD100480
      B7(K)=FB                                                       RD100490
10    CCNTINUE                                                       RD100500
      DO 130 I=1,7                                                   RD100510
      READ (IR,140) (AA(L),L=1,72)                                   RD100520
      DO 20 J=1,72                                                   RD100530
      IF (AA(J).EQ.FB) GC TO 20                                      RD100540
      N=73-J                                                         RD100550
      JJ=J                                                           RD100560
      GO TC 30                                                       RD100570
20    CONTINUE                                                       RD100580
      GO TC 130                                                      RD100590
30    DO 120 K=1,N                                                   RD100600
C*****************************************************************RD100610
C**   MOVE NCN-ELANK CHARACTERS TO BEGINNING OF FIELD              **RD100620
C*****************************************************************RD100630
      GO TC (40,50,60,70,80,  90,100), I                             RD100640
40    L1=N                                                           RD100650
      B1(K)=AA(JJ)                                                   RD100660
      IF (K.NE.4) GO TO 110                                          RD100670
C*****************************************************************RD100680
C**  TEST TO SEE IF CARD HAS STCP CN IT , IF IT DCES THEN STOP THE  **RD100690
C**  PROGRAM CTHERWISE CCNTINUE                                     **RD100700
C*****************************************************************RD100710
      IF (B1(1).EQ.FS.AND.B1(2).EQ.FT.AND.B1(3).EC.FO.AND.B1(4).EQ.FP) SRD100720
     2TOP                                                            RD100730
      GO TC 110                                                      RD100740
50    L2=N                                                           RD100750
      B2(K)=AA(JJ)                                                   RD100760
      GO TO 110                                                      RD100770
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60    L3=N                                                              RD100780
      B3(K)=AA(JJ)                                                      RD100790
      GO TO 110                                                         RD100800
70    L4=N                                                              RD100810
      B4(K)=AA(JJ)                                                      RD100820
      GO TO 110                                                         RD100830
80    L5=N                                                              RD100840
      B5(K)=AA(JJ)                                                      RD100850
      GO TO 110                                                         RD100860
90    L6=N                                                              RD100870
      B6(K)=AA(JJ)                                                      RD100880
      GO TO 110                                                         RD100890
100   B7(K)=AA(JJ)                                                      RD100900
110   JJ=JJ+1                                                           RD100910
120   CONTINUE                                                          RD100920
130   CONTINUE                                                          RD100930
C*****************************************************************RD100940
C**   READ RANDOM ERROR LIMIT, SYSTEMATIC ERROR LIMIT AND NOMINAL     **RD100950
C**   TEMPERATURE ALL ON ONE CARD FREE FIELD ,FIELDS MUST BE          **RD100960
C**   SEPARATED BY A BLANK OR ANY NON-NUMERIC CHARACTER EXCEPT FOR    **RD100970
C**   D OR E OR .                                                     **RD100980
C**                                                                   **RD100990
C**   WHERE THE NUMBERS MUST BE IN THE FOLLOWING ORDER                **RD101000
C**     RANERR = 3 TIMES RANDOM ERROR IN THE STARTING RESTRAINT IN MG **RD101010
C**     SYSERR = SYSTEMATIC ERROR IN THE STARTING RESTRAINT IN MG     **RD101020
C**     TNOM   = NOMINAL TEMPERATURE AT WHICH THE APPARENT MASS       **RD101030
C**              VALUES ARE REPORTED IN DEGREES C                     **RD101040
C**     IBREST = STARTING RESTRAINT ID NUMBER                         **RD101050
C**                                                                   **RD101060
C**   FOR THE REST OF THE INPUT CARDS FOR EACH SERIES OF WEIGHINGS    **RD101070
C**   LOOK AT COMMENTS CARDS IN SUBROUTINE READ2                      **RD101080
C*****************************************************************RD101090
      CALL READIT (AA,1,AAITEM)                                         RD101100
      RANERR=AA(1)                                                      RD101110
      SYSERR=AA(2)                                                      RD101120
      TNOM=AA(3)                                                        RD101130
      IBREST=INT(AA(4)+.5)                                              RD101140
      RETURN                                                            RD101150
C*****************************************************************RD101160
C**   FORMAT STATEMENT                                               **RD101170
C*****************************************************************RD101180
140   FORMAT (72A1)                                                     RD101190
      END                                                               RD101200
--- READIT SUBPROGRAM ---
      SUBROUTINE READIT (Z,KOL,A)                                       RDT00010
C*****************************************************************RDT00020
C**   SUBROUTINE OF THE NATIONAL BUREAU OF STANDARDS MASS CALIBRATION **RDT00030
C**   PROGRAM  VERSION OF SEPT.10,1971     WRITTEN BY R.C.RAYBOLD     **RDT00040
C**   AND MRS.R.N.VARNER                                              **RDT00050
C**   MODIFIED BY R. N. VARNER SEPT 1979                              **RDT00060
C*****************************************************************RDT00070
C**   ANSI FORTRAN SUBROUTINE TO READ NUMBERS IN ANY FORMAT ANYWHERE  **RDT00080
C**   ON A CARD (BETWEEN CARD COLUMNS 'KOL' AND 80, INCLUSIVE).       **RDT00090
C**   IN THIS VERSION OF THE SUBROUTINE, WHEN KOL = 16, CARD COLUMNS  **RDT00100
C**   1 THROUGH 15 ARE SCANNED TO PICK UP ALPHA-NUMERIC DATA WHICH    **RDT00110
C**   ARE STORED IN VARIABLE 'A'.                                     **RDT00120
C**   WRITTEN BY ROY H. WAMPLER, STATISTICAL ENGINEERING LABORATORY,  **RDT00130
C**   NATIONAL BUREAU OF STANDARDS, WASHINGTON, D. C. 20234           **RDT00140
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C**   VERSION OF FEBRUARY 8, 1971                                        **RDT00150
C*************************************************************************RDT00160
C**   NUMBERS TO BE READ BY THIS ROUTINE SHOULD OBEY THE FOLLOWING       **RDT00170
C**   RULES.                                                             **RDT00180
C**                                                                      **RDT00190
C**   (1)  BETWEEN ANY TWO NUMBERS THERE MUST BE A SEPARATOR.  THIS      **RDT00200
C**   CAN BE ONE OR MORE BLANK SPACES, A COMMA, ANY LETTER EXCEPT D      **RDT00210
C**   OR E, OR ANY CHARACTER EXCEPT A PLUS SIGN, A MINUS SIGN, OR A      **RDT00220
C**   DECIMAL.                                                           **RDT00230
C**                                                                      **RDT00240
C**   (2)  NUMBERS CAN APPEAR IN INTEGER FORM.  EXAMPLES ARE             **RDT00250
C**   0  63  -271  +81063  01  2.71,-534.28                              **RDT00260
C**                                                                      **RDT00270
C**   (3)  NUMBERS CAN BE WRITTEN WITH A DECIMAL POINT.  EXAMPLES ARE    **RDT00280
C**   0. -1.0  38.1  -63.  .00015  +371.286                              **RDT00290
C**                                                                      **RDT00300
C**   (4)  NUMBERS CAN BE WRITTEN WITH AN EXPONENT WHICH MUST BE         **RDT00310
C**   PRECEDED BY A D OR E.  (IN THIS ROUTINE D IS CONSIDERED EQUIVA-    **RDT00320
C**   LENT TO E, AND NUMBERS WITH D ARE NOT INTERPRETED TO BE            **RDT00330
C**   DOUBLE PRECISION NUMBERS.)  EXAMPLES ARE                           **RDT00340
C**    2.1E12  2.1E 12  2.1E+12  2.1E-12                                 **RDT00350
C**   -2.1D12 -2.1D 12 -2.1D+12 -2.1D-12                                 **RDT00360
C**   0021.E02 .00021E5 2.1E0 2.1E-0                                     **RDT00370
C**   21E12  21E+12  21D-12                                              **RDT00380
C**   THE LAST THREE EXAMPLES ILLUSTRATE THAT A DECIMAL NEED NOT BE      **RDT00390
C**   USED IN CONNECTION WITH THE D OR E.                                **RDT00400
C*************************************************************************RDT00410
      DIMENSION Z(40),A(1),N(80),IDIGIT(10),T(77)                         RDT00420
      COMMON /DPFDVL/ KFD(18)                                             RDT00430
      COMMON /UNITIO/ IR,IW,IP,IPL,ITMP                                   RDT00440
      EQUIVALENCE (IDIGIT(1),KFD(1))                                      RDT00450
      EQUIVALENCE (IPLUS,KFD(15))                                         RDT00460
      EQUIVALENCE (IMINUS,KFD(12))                                        RDT00470
      EQUIVALENCE (ID,KFD(17))                                            RDT00480
      EQUIVALENCE (IE,KFD(18))                                            RDT00490
      EQUIVALENCE (IDECML,KFD(13))                                        RDT00500
      EQUIVALENCE (IBLANK,KFD(11))                                        RDT00510
C*************************************************************************RDT00520
C**   THE FOLLOWING DIMENSION STATEMENT AND THE THREE DATA STATEMENTS     **RDT00530
C**   WHICH FOLLOW THAT ARE MACHINE-DEPENDENT.                           **RDT00540
C**   T(I) CONTAINS THE MACHINE RANGE OF NUMBERS                         **RDT00550
C**      IN THIS CASE 1.E-38 TO 1.E38                                    **RDT00560
C**   IZERO = NUMBER OF UNIQUE POWERS OF TEN REPRESENTED BY              **RDT00570
C**           THE MACHINE RANGE                                          **RDT00580
C**   MAX = NUMBER OF POWERS OF TEN (NEGATIVE AND POSITIVE)              **RDT00590
C**         REPRESENTED BY THE MACHINE RANGE                             **RDT00600
C*************************************************************************RDT00610
      DATA T(1),T(2),T(3),T(4),T(5),T(6),T(7),T(8),T(9),T(10),T(11),      RDT00620
     2 T(12),T(13),T(14),T(15),T(16),T(17),T(18),T(19),T(20),T(21),T(22)RDT00630
     3,T(23),T(24),T(25),T(26),T(27),T(28),T(29),T(30),T(31),T(32),T(33)RDT00640
     4,T(34),T(35),T(36),T(37),T(38),T(39),T(40),T(41),T(42),T(43),T(44)RDT00650
     5,T(45),T(46),T(47),T(48),T(49),T(50),T(51),T(52),T(53),T(54),T(55)RDT00660
     6,T(56),T(57),T(58),T(59),T(60),T(61),T(62),T(63),T(64),T(65),T(66)RDT00670
     7,T(67),T(68),T(69),T(70),T(71),T(72),T(73),T(74),T(75),T(76),      RDT00680
     8 T(77) /1.E-38,1.E-37,1.E-36,1.E-35,1.E-34,1.E-33,1.E-32,1.E-31,   RDT00690
     9 1.E-30,1.E-29,1.E-28,1.E-27,1.E-26,1.E-25,1.E-24,1.E-23,1.E-22,   RDT00700
     * 1.E-21,1.E-20,1.E-19,1.E-18,1.E-17,1.E-16,1.E-15,1.E-14,1.E-13,   RDT00710
     1 1.E-12,1.E-11,1.E-10,1.E-9,1.E-8,1.E-7,1.E-6,1.E-5,1.E-4,1.E-3,   RDT00720
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     2 1.E-2,1.E-1,1.,1.E1,1.E2,1.E3,1.E4,1.E5,1.E6,1.E7,1.E8,1.E9,1.E10RDT00730
     3,1.E11,1.E12,1.E13,1.E14,1.E15,1.E16,1.E17,1.E18,1.E19,1.E20,1.E21RDT00740
     4,1.E22,1.E23,1.E24,1.E25,1.E26,1.E27,1.E28,1.E29,1.E30,1.E31,1.E32RDT00750
     5,1.E33,1.E34,1.E35,1.E36,1.E37,1.E38/                              RDT00760
      DATA IZERO,IMAX /39,77/                                            RDT00770
C*****************************************************************RDT00780
C**   THE DIMENSIONED VARIABLE T IS USED FOR ENTERING POWERS OF TEN   **RDT00790
C**   INTO THE PROGRAM.                                               **RDT00800
C**   IZERO IS THE SUBSCRIPT OF T SUCH THAT T(IZERO) = 1. (= 1.E0).   **RDT00810
C**   (ON THE UNIVAC 1108, T(IZERO) = T(39).)                         **RDT00820
C**   IMAX IS THE LARGEST SUBSCRIPT OF T.                             **RDT00830
C**   IN THE PROGRAM IT IS ASSUMED THAT (1 + IMAX)/2 = IZERO.  THAT   **RDT00840
C**   IS, WE ASSUME THAT VALID SINGLE PRECISION NUMBERS RANGE IN      **RDT00850
C**   ABSOLUTE VALUE FROM 10.**(1 - IZERO) TO 10.**(IZERO - 1), OR ARE**RDT00860
C**   EQUAL TO ZERO.                                                  **RDT00870
C**   NR IS THE COMPUTER'S READING UNIT, AND NW ITS WRITING UNIT.     **RDT00880
C*****************************************************************RDT00890
C**   CHARACTERS OF INTEREST ARE IN KFD                               **RDT00900
C**   THEY WILL BE COMPARED WITH N                                    **RDT00910
C*****************************************************************RDT00920
C*****************************************************************RDT00930
C**   THE CHARACTERS ON ONE CARD ARE READ IN AN A-FORMAT AND STORED   **RDT00940
C**   IN N.                                                           **RDT00950
C*****************************************************************RDT00960
      IF (KOL.GE.1.AND.KOL.LE.80) GO TO 10                             RDT00970
      CALL ERROR (KOL,A,N,LL,IW,7)                                     RDT00980
      RETURN                                                           RDT00990
10    IF (KOL.EQ.16) GO TO 20                                          RDT01000
      READ (IR,1010) (N(I),I=1,80)                                     RDT01010
      GO TO 30                                                         RDT01020
20    READ (IR,1000) (A(I),I=1,5),(N(I),I=16,80)                       RDT01030
C*****************************************************************RDT01040
C**   ON SOME COMPUTERS THE FORMAT FOR READING A(I) MAY HAVE TO BE    **RDT01050
C**   CHANGED.                                                        **RDT01060
C*****************************************************************RDT01070
C**   APPROPRIATE VARIABLES ARE INITIALIZED.                          **RDT01080
C*****************************************************************RDT01090
30    IDORE=0                                                          RDT01100
      IEXP=0                                                           RDT01110
      ISIGX=0                                                          RDT01120
      K=0                                                              RDT01130
      NDE=0                                                            RDT01140
      NDEC=0                                                           RDT01150
      NODEC=0                                                          RDT01160
      NUME=0                                                           RDT01170
      NXDIG=0                                                          RDT01180
      SIG=0.                                                           RDT01190
      SIGN=0.                                                          RDT01200
      DO 40 I=1,40                                                     RDT01210
40    Z(I)=0.                                                          RDT01220
C*****************************************************************RDT01230
C**   THE CHARACTERS ON THE CARD ARE EXAMINED.                        **RDT01240
C**   WHEN NUMBERS ARE FOUND THEY ARE STORED IN Z(K).                 **RDT01250
C*****************************************************************RDT01260
      DO 580 I=KOL,80                                                  RDT01270
C*****************************************************************RDT01280
C**   DETERMINE IF N(I) IS A DIGIT.                                   **RDT01290
C*****************************************************************RDT01300
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      IF (N(I).GE.IDIGIT(1).AND.N(I).LE.IDIGIT(10)) GO TO 520          RDT01310
C*************************************************************************RDT01320
C**   N(I) IS NOT A DIGIT.                                              **RDT01330
C**   DETERMINE IF N(I) IS A PLUS, MINUS, DECIMAL, D, E, OR BLANK.      **RDT01340
C*************************************************************************RDT01350
      IF (NUMB) 140,50,140                                             RDT01360
50    IF (N(I)-IPLUS) 60,130,60                                        RDT01370
60    IF (N(I)-IMINUS) 70,100,70                                       RDT01380
70    IF (N(I)-IDECML) 80,90,80                                        RDT01390
80    NDE=0                                                            RDT01400
      SIG=0.                                                           RDT01410
      GO TO 780                                                        RDT01420
90    NDE=1                                                            RDT01430
      GO TO 780                                                        RDT01440
100   SIG=-1.                                                          RDT01450
110   IF (NDE) 120,780,120                                             RDT01460
120   NDE=0                                                            RDT01470
      GO TO 780                                                        RDT01480
130   SIG=1.                                                           RDT01490
      GO TO 110                                                        RDT01500
140   IF (IDCRE) 340,150,340                                           RDT01510
150   IF (NDEC) 250,160,250                                            RDT01520
160   IF (N(I)-ID) 180,170,180                                         RDT01530
170   IDORE=1                                                          RDT01540
      NODEC=1                                                          RDT01550
      GO TO 780                                                        RDT01560
180   IF (N(I)-IE) 190,170,190                                         RDT01570
190   IF (N(I)-IDECML) 210,200,210                                     RDT01580
200   NDEC=1                                                           RDT01590
      GO TO 780                                                        RDT01600
210   IF (N(I)-IPLUS) 230,220,230                                      RDT01610
220   SIG=1.                                                           RDT01620
      GO TO 850                                                        RDT01630
230   IF (N(I)-IMINUS) 850,240,850                                     RDT01640
240   SIG=-1.                                                          RDT01650
      GO TO 850                                                        RDT01660
250   IF (N(I)-ID) 270,260,270                                         RDT01670
260   IDORE=1                                                          RDT01680
      GO TO 780                                                        RDT01690
270   IF (N(I)-IE) 280,260,280                                         RDT01700
280   IF (N(I)-IDECML) 300,290,300                                     RDT01710
290   NDE=1                                                            RDT01720
      GO TO 870                                                        RDT01730
300   IF (N(I)-IPLUS) 320,310,320                                      RDT01740
310   SIG=1.                                                           RDT01750
      GO TO 870                                                        RDT01760
320   IF (N(I)-IMINUS) 870,330,870                                     RDT01770
330   SIG=-1.                                                          RDT01780
340   IF (N(I)-IDECML) 370,350,370                                     RDT01790
350   NDE=1                                                            RDT01800
      IF (NXDIG) 870,360,870                                           RDT01810
360   IF (NDEC) 870,850,870                                            RDT01820
370   IF (IDCRE-1) 380,440,380                                         RDT01830
380   IF (N(I)-IPLUS) 400,390,400                                      RDT01840
390   SIG=1.                                                           RDT01850
      GO TO 420                                                        RDT01860
400   IF (N(I)-IMINUS) 420,410,420                                     RDT01870
410   SIG=-1.                                                          RDT01880
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420   IF (NXDIG) 870,430,870                                          RDT01890
430   IF (NDEC) 870,850,870                                           RDT01900
440   IF (NXDIG) 870,450,870                                          RDT01910
450   IF (N(I)-IMINUS) 460,510,460                                    RDT01920
460   IF (N(I)-IPLUS) 470,490,470                                     RDT01930
470   IF (N(I)-IBLANK) 480,490,480                                    RDT01940
480   IF (NDEC) 870,850,870                                           RDT01950
490   ISIGX=1                                                         RDT01960
500   IDCRE=ICORE+1                                                   RDT01970
      GO TO 780                                                       RDT01980
510   ISIGX=-1                                                        RDT01990
      GO TO 500                                                       RDT02000
C*****************************************************************RDT02010
C**   N(I) IS A DIGIT.                                            **RDT02020
C*****************************************************************RDT02030
520   IF (NUMB) 530,540,530                                           RDT02040
530   IF (IDCRE) 730,650,730                                          RDT02050
C*****************************************************************RDT02060
C**   N(I) IS THE FIRST DIGIT OF A NUMBER.                        **RDT02070
C*****************************************************************RDT02080
540   IF (SIG) 550,560,550                                            RDT02090
550   SIGN=SIG                                                        RDT02100
      SIG=0.                                                          RDT02110
      GO TO 570                                                       RDT02120
560   SIGN=1.                                                         RDT02130
570   IF (NDE) 580,590,580                                            RDT02140
580   NDEC=NDE+1                                                      RDT02150
      NDE=0                                                           RDT02160
590   DO 600 L=1,10                                                   RDT02170
      IF (N(I).NE.IDIGIT(L)) GO TO 600                                RDT02180
      IN=L-1                                                          RDT02190
      GO TO 610                                                       RDT02200
600   CONTINUE                                                        RDT02210
610   ZED=IN                                                          RDT02220
      IF (ZED) 620,630,620                                            RDT02230
620   LL=1                                                            RDT02240
      GO TO 640                                                       RDT02250
630   LL=0                                                            RDT02260
640   NUME=1                                                          RDT02270
      GO TO 780                                                       RDT02280
C*****************************************************************RDT02290
C**   N(I) IS THE J-TH DIGIT OF A NUMBER WHERE J IS GREATER THAN  **RDT02300
C**   ONE.                                                        **RDT02310
C*****************************************************************RDT02320
650   IF (NDEC) 660,670,660                                           RDT02330
660   NDEC=NDEC+1                                                     RDT02340
670   DO 680 L=1,10                                                   RDT02350
      IF (N(I).NE.IDIGIT(L)) GO TO 680                                RDT02360
      IN=L-1                                                          RDT02370
      GO TO 690                                                       RDT02380
680   CONTINUE                                                        RDT02390
690   FIN=IN                                                          RDT02400
      ZED=10.*ZED+FIN                                                 RDT02410
      IF (ZED) 700,780,700                                            RDT02420
700   LL=LL+1                                                         RDT02430
      IF (LL.LT.IZERO) GO TO 780                                      RDT02440
      IF (LL.EQ.IZERO) GO TO 710                                      RDT02450
      GO TO 720                                                       RDT02460
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710   CALL ERROR (KOL,A,N,LL,IW,1)                                    RDT02470
      GO TO 780                                                       RDT02480
720   CALL ERROR (KOL,A,N,LL,IW,2)                                    RDT02490
      GO TO 990                                                       RDT02500
C*****************************************************************RDT02510
C**   N(I) IS AN EXPONENTIAL DIGIT.                               **RDT02520
C*****************************************************************RDT02530
730   IF (IDONE-1) 750,740,750                                        RDT02540
740   ISIGX=1                                                         RDT02550
750   DO 760 L=1,10                                                   RDT02560
      IF (N(I).NE.IDIGIT(L)) GO TO 760                                RDT02570
      IN=L-1                                                          RDT02580
      GO TO 770                                                       RDT02590
760   CONTINUE                                                        RDT02600
770   IEXP=10*IEXP+IN                                                 RDT02610
      NXDIG=NXDIG+1                                                   RDT02620
      GO TO 780                                                       RDT02630
C*****************************************************************RDT02640
C**   DETERMINE IF THE LAST COLUMN OF THE CARD HAS BEEN REACHED.  **RDT02650
C*****************************************************************RDT02660
780   IF (I-80) 980,790,790                                           RDT02670
C*****************************************************************RDT02680
C**   LAST COLUMN HAS BEEN REACHED.                               **RDT02690
C**   END-OF-CARD ROUTINE IS NOW EXECUTED.                        **RDT02700
C*****************************************************************RDT02710
790   IF (IDONE) 830,800,830                                          RDT02720
800   IF (NUMB) 820,810,820                                           RDT02730
810   SIG=0.                                                          RDT02740
      NDE=0                                                           RDT02750
      GO TO 980                                                       RDT02760
820   IF (NDEC) 870,850,870                                           RDT02770
830   IF (NXDIG) 870,840,870                                          RDT02780
840   IF (NDEC) 870,850,870                                           RDT02790
C*****************************************************************RDT02800
C**   K-TH NUMBER (WHICH APPEARED IN INTEGER FORM) IS STORED AS   **RDT02810
C**   Z(K).                                                       **RDT02820
C*****************************************************************RDT02830
850   K=K+1                                                           RDT02840
      IF (ZED) 860,960,860                                            RDT02850
860   Z(K)=SIGN*ZED                                                   RDT02860
      GO TO 970                                                       RDT02870
C*****************************************************************RDT02880
C**   K-TH NUMBER (WHICH APPEARED IN NON-INTEGER FORM) IS STORED AS**RDT02890
C**   Z(K).                                                       **RDT02900
C*****************************************************************RDT02910
870   K=K+1                                                           RDT02920
      NDEC=NDEC+NODEC                                                 RDT02930
      IF (ZED) 880,960,880                                            RDT02940
880   KK=LL+ISIGX*IEXP-NDEC+1                                         RDT02950
      IF (KK.GT.(1-IZERO).AND.KK.LT.IZERO) GO TO 930                  RDT02960
      IF (KK.LT.(1-IZERO)) GO TO 890                                  RDT02970
      IF (KK.EQ.(1-IZERO)) GO TO 900                                  RDT02980
      IF (KK.EQ.IZERO) GO TO 910                                      RDT02990
      IF (KK.GT.IZERO) GO TO 920                                      RDT03000
890   CALL ERROR (KOL,A,N,LL,IW,3)                                    RDT03010
      GO TO 930                                                       RDT03020
900   CALL ERROR (KOL,A,N,LL,IW,4)                                    RDT03030
      GO TO 930                                                       RDT03040
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910   CALL ERROR (KOL,A,N,LL,IW,5)                                    RDT03050
      GO TO 930                                                       RDT03060
920   CALL ERROR (KOL,A,N,LL,IW,6)                                    RDT03070
      GO TO 930                                                       RDT03080
930   M=KK-LL+IZERO                                                   RDT03090
      IF (M.LE.0.OR.M.GT.IMAX) GO TO 940                              RDT03100
      Z(K)=SIGN*ZED*T(M)                                              RDT03110
      GO TO 970                                                       RDT03120
940   M=IZERO-LL                                                      RDT03130
      IF (M.NE.0) GO TO 950                                           RDT03140
C*************************************************************************RDT03150
C**   M IS EQUAL TO ZERO (SPECIAL CASE)                              **RDT03160
C*************************************************************************RDT03170
      M=M+1                                                           RDT03180
      ZED=ZED*T(M)                                                    RDT03190
      M=KK+IZERO-1                                                    RDT03200
      Z(K)=SIGN*ZED*T(M)                                              RDT03210
      GO TO 970                                                       RDT03220
C*************************************************************************RDT03230
C**   M IS NOT EQUAL TO ZERO                                         **RDT03240
C*************************************************************************RDT03250
950   ZED=ZED*T(M)                                                    RDT03260
      M=KK+IZERO                                                      RDT03270
      Z(K)=SIGN*ZED*T(M)                                              RDT03280
      GO TO 970                                                       RDT03290
960   Z(K)=0.                                                         RDT03300
C*************************************************************************RDT03310
C**   APPROPRIATE VARIABLES ARE RE-INITIALIZED.                      **RDT03320
C*************************************************************************RDT03330
970   IDORE=0                                                         RDT03340
      IEXP=0                                                          RDT03350
      ISIGX=0                                                         RDT03360
      KK=0                                                            RDT03370
      LL=0                                                            RDT03380
      M=0                                                             RDT03390
      NDEC=0                                                          RDT03400
      NODEC=0                                                         RDT03410
      NUME=0                                                          RDT03420
      NXDIG=0                                                         RDT03430
      SIGN=0.                                                         RDT03440
980   CONTINUE                                                        RDT03450
      RETURN                                                          RDT03460
990   KK=0                                                            RDT03470
      LL=0                                                            RDT03480
      M=0                                                             RDT03490
      RETURN                                                          RDT03500
C*************************************************************************RDT03510
C**   FORMAT STATEMENTS.                                             **RDT03520
C*************************************************************************RDT03530
1000  FORMAT (5A3,65A1)                                               RDT03540
1010  FORMAT (80A1)                                                   RDT03550
      END                                                             RDT03560
--- ERROR SUBPROGRAM ---
      SUBROUTINE ERROR (KOL,A,N,LL,IW,KEY)                            ERR00010
C*************************************************************************ERR00020
C**   SUBROUTINE OF THE NATIONAL BUREAU OF STANDARDS MASS CALIBRATION **ERR00030
C**   PROGRAM  VERSION OF SEPT.10,1971     WRITTEN BY R.C.RAYBOLD     **ERR00040
C**   AND MRS.R.N.VARNER                                             **ERR00050
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C**   MODIFIED BY R. N. VARNER SEPT 1979                              **ERR00060
C*****************************************************************ERR00070
C**   SUBROUTINE OF THE DIAGNOSTIC OUTPUT FOR READIT SUBROUTINE      **ERR00080
C*****************************************************************ERR00090
      DIMENSION A(1),N(1)                                             ERR00100
      GO TO (10,20,30,40,50,  60,70), KEY                             ERR00110
10    WRITE (IW,100) LL                                               ERR00120
      IF (KOL-16) 90,80,90                                            ERR00130
20    WRITE (IW,110) LL                                               ERR00140
      IF (KOL-16) 90,80,90                                            ERR00150
30    WRITE (IW,120)                                                  ERR00160
      IF (KOL-16) 90,80,90                                            ERR00170
40    WRITE (IW,130)                                                  ERR00180
      IF (KOL-16) 90,80,90                                            ERR00190
50    WRITE (IW,140)                                                  ERR00200
      IF (KOL-16) 90,80,90                                            ERR00210
60    WRITE (IW,150)                                                  ERR00220
      IF (KOL-16) 90,80,90                                            ERR00230
70    WRITE (IW,160) KOL                                              ERR00240
      RETURN                                                          ERR00250
80    WRITE (IW,180)                                                  ERR00260
      WRITE (IW,170) (A(I),I=1,5),(N(I),I=16,80)                      ERR00270
      RETURN                                                          ERR00280
90    WRITE (IW,180)                                                  ERR00290
      WRITE (IW,190) (N(I),I=1,80)                                    ERR00300
      RETURN                                                          ERR00310
C*****************************************************************ERR00320
C**   FORMAT STATEMENTS                                             **ERR00330
C*****************************************************************ERR00340
100   FORMAT (25H0*****  DIAGNOSTIC  *****/1X,                       ERR00350
     2 64H*****  THE NUMBER OF SIGNIFICANT DIGITS IN A NUMBER HAS REACHEERR00360
     3D ,I3,42H.  THIS MAY PRODUCE OVERFLOW OR UNDERFLOW.)            ERR00370
110   FORMAT (20H0*****  ERROR  *****/1X,                            ERR00380
     2 64H*****  THE NUMBER OF SIGNIFICANT DIGITS IN A NUMBER HAS REACHEERR00390
     3D ,I3,43H.  THIS WILL PRODUCE OVERFLOW OR UNDERFLOW.)           ERR00400
120   FORMAT (87H0*****  ERROR  *****  NUMBER IS TOO SMALL IN ABSOLUTE VERR00410
     2ALUE AND WILL PRODUCE UNDERFLOW.)                               ERR00420
130   FORMAT (87H0*****  DIAGNOSTIC  *****  NUMBER IS SMALL IN ABSOLUTE ERR00430
     2VALUE AND MAY PRODUCE UNDERFLOW.)                               ERR00440
140   FORMAT (86H0*****  DIAGNOSTIC  *****  NUMBER IS LARGE IN ABSOLUTE ERR00450
     2VALUE AND MAY PRODUCE OVERFLOW.)                                ERR00460
150   FORMAT (86H0*****  ERROR  *****  NUMBER IS TOO LARGE IN ABSOLUTE VERR00470
     2ALUE AND WILL PRODUCE OVERFLOW.)                                ERR00480
160   FORMAT (44H0*****  ERROR  *****  THE VALUE OF 'KOL' IS ,I6,      ERR00490
     2 27H AND THIS VALUE IS INVALID./1X,                             ERR00500
     3 50HKOL MUST BE GREATER THAN 0 AND MUST NOT EXCEED 80.)         ERR00510
170   FORMAT (1H ,5A3,65A1)                                           ERR00520
180   FORMAT (72H THIS OCCURRED IN CONNECTION WITH READING THE DATA ON TERR00530
     2HE FOLLOWING CARD)                                              ERR00540
190   FORMAT (1H ,80A1)                                               ERR00550
      END                                                             ERR00560
--- PRINT1 SUBPROGRAM ---
      SUBROUTINE PRINT1                                               PR100010
C*****************************************************************PR100020
C**   SUBROUTINE OF THE NATIONAL BUREAU OF STANDARDS MASS CALIBRATION **PR100030
C**   PROGRAM  VERSION OF SEPT. 10,1971    WRITTEN BY R.C.RAYFIELD    **PR100040
C**   AND MRS.R.N.VARNER                                              **PR100050
C**   MODIFIED BY R. N. VARNER SEPT 1979                              **PR100060
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C*****************************************************************PR100070
C**  SUBRCUTINE TO PRINT TITLE PAGE   1/12/70                    **PR100080
C*****************************************************************PR100090
C**   DIMENSICN FCR COMMCN /PRT1/ VARIABLES                      **PR100100
C*****************************************************************PR100110
      DIMENSICN B1(72),B2(72),B3(72),B4(72),B5(72),B6(72),B7(72),     PR100120
     2 IDATE(3)                                                       PR100130
C*****************************************************************PR100140
C**   LABELED COMMON                                             **PR100150
C*****************************************************************PR100160
      COMMON /PRT1/ B1,B2,B3,B4,B5,B6,B7,RANERR,SYSERR,TNOM,L1,L2,L3,L4,PR100170
     2 L5,L6,IDATE,IBREST                                             PR100180
      COMMCN /PRT2/ IPAGE,NOSER,IPGCT                                 PR100190
      COMMON /UNITIO/ IR,IW,IP,IPL,ITMP                               PR100200
      WRITE (IW,80)                                                   PR100210
      WRITE (IW,90) (B1(K),K=1,L1)                                    PR100220
      WRITE (IW,90) (B2(K),K=1,L2)                                    PR100230
      WRITE (IW,90) (B3(K),K=1,L3)                                    PR100240
      WRITE (IW,90) (B4(K),K=1,L4)                                    PR100250
      WRITE (IW,90) (B5(K),K=1,L5)                                    PR100260
      WRITE (IW,90) (B6(K),K=1,L6)                                    PR100270
      WRITE (IW,100) (B7(K),K=1,18)                                   PR100280
      DO 70 I=1,6                                                     PR100290
      IPAGE=IPAGE+1                                                   PR100300
      WRITE (IW,110) (B1(K),K=1,65),IPAGE                             PR100310
      WRITE (IW,120) (B2(K),K=1,L2)                                   PR100320
      WRITE (IW,120) (B3(K),K=1,L3)                                   PR100330
      WRITE (IW,130) (B7(K),K=1,18)                                   PR100340
      GO TO (10,20,30,40,50,  60), IPAGE                              PR100350
10    CALL TEXT1                                                      PR100360
      GO TO 70                                                        PR100370
20    CALL TEXT2                                                      PR100380
      GO TO 70                                                        PR100390
30    CALL TEXT3                                                      PR100400
      GO TC 70                                                        PR100410
40    CALL TEXT4                                                      PR100420
      GO TC 70                                                        PR100430
50    CALL TEXT5                                                      PR100440
      GO TC 70                                                        PR100450
60    CALL TEXT6                                                      PR100460
70    CONTINUE                                                        PR100470
      RETURN                                                          PR100480
C*****************************************************************PR100490
C**   FORMAT STATEMENTS                                          **PR100500
C*****************************************************************PR100510
80    FORMAT (1H1,45X,28HU. S. DEPARTMENT OF COMMERCE/46X,            PR100520
     2 28HNATIONAL BUREAU OF STANDARDS/45X,                           PR100530
     3 31HNATIONAL ENGINEERING LABORATORY/48X,22HWASHINGTON, D.C. 20234/PR100540
     4////////////////59X,11HR E P O R T/55X,3HO F/51X,                PR100550
     5 22HM A S S    V A L U E S/)                                   PR100560
90    FORMAT (43X,72A1)                                               PR100570
100   FORMAT (////////////26X,11HTEST NUMBER,2X,18A1///60X,           PR100580
     2 17HFOR THE DIRECTOR,////60X,22HG. E. MATTINGLY, CHIEF/60X,     PR100590
     3 26HFLUID ENGINEERING DIVISICN/60X,                             PR100600
     4 33HCENTER FOR MECHANICAL ENGINEERING/62X,                      PR100610
     5 22HAND PROCESS TECHNOLOGY/60X,                                PR100620
     6 31HNATIONAL ENGINEERING LABORATORY)                           PR100630
110   FORMAT (1H1,65A1,4HPAGE,I3)                                     PR100640
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120   FORMAT (1X,72A1)                                                    PR100650
130   FORMAT (1X,13HTEST NUMBER  ,18A1)                                   PR100660
      END                                                                 PR100670
--- TEXT1 SUBPROGRAM ---
      SUBROUTINE TEXT1                                                    TX100010
C*****************************************************************TX100020
C**   SUBROUTINE OF THE NATIONAL BUREAU OF STANDARDS MASS CALIBRATION **TX100030
C**   PROGRAM  VERSION OF SEPT. 10,1971    WRITTEN BY R.C.RAYBOLD     **TX100040
C**   AND MRS.R.N.VARNER                                              **TX100050
C**   MODIFIED BY R. N. VARNER SEPT 1979                              **TX100060
C*****************************************************************TX100070
      COMMON/UNITIO/IR,IW,IP,IPL,ITMF                                     TX100080
      WRITE (IW,10)                                                       TX100090
      WRITE (IW,20)                                                       TX100100
      WRITE (IW,30)                                                       TX100110
      WRITE (IW,40)                                                       TX100120
      WRITE (IW,50)                                                       TX100130
      WRITE (IW,60)                                                       TX100140
      WRITE (IW,70)                                                       TX100150
      WRITE (IW,80)                                                       TX100160
      WRITE (IW,90)                                                       TX100170
      WRITE (IW,100)                                                      TX100180
      WRITE (IW,110)                                                      TX100190
      RETURN                                                              TX100200
C*****************************************************************TX100210
C**   FORMAT STATEMENTS                                               **TX100220
C*****************************************************************TX100230
10    FORMAT (/)                                                          TX100240
20    FORMAT (1X,36H            INTRODUCTION                ,             TX100250
     236H  WHICH RELY, DIRECTLY OR  INDIRECT-/                            TX100260
     31X,36H                                  ,                           TX100270
     436H  LY,  ON  MASS  MEASUREMENTS  TO/                               TX100280
     51X,36H    THIS DOCUMENT IS A COMPREHEN-  ,                          TX100290
     636H  ACCOMPLISH  A  WIDE  VARIETY  OF/                              TX100300
     71X,36HSIVE REPORT COVERING THE SEQUENCE  ,                          TX100310
     836H  ENDEAVORS.    IN  ORDER  FOR  THIS/                            TX100320
     91X,36HOF OPERATIONS USED TO ASSIGN  MASS  ,                         TX100330
     *36H  SYSTEM  TO  FUNCTION  PROPERLY,)                               TX100340
30    FORMAT (1X,36HVALUES  TO  THE  WEIGHTS  IDENTIFIED  ,                TX100350
     236H  EVERYONE  WHO  MAKES  MEASUREMENTS/                            TX100360
     31X,36HABOVE.   IT  INCLUDES  A  COMPLETE  ,                         TX100370
     436H  MUST BE ABLE TO  VERIFY  THAT  HIS/                            TX100380
     51X,36HDESCRIPTION  OF  THE  MEASUREMENT  ,                          TX100390
     636H  MEASUREMENT   PROCESS   PRODUCES/                              TX100400
     71X,36HMETHODS AND PROCEDURES WHICH  WERE  ,                         TX100410
     836H  CONSISTENT  RESULTS  WHICH  ARE/                               TX100420
     91X,36HUSED,  ALL  OF  THE  DATA, AND THE  ,                         TX100430
     *36H  COMPATIBLE  WITH  HIS  PARTICULAR)                             TX100440
40    FORMAT (1X,36HANALYSIS  OF  THIS  DATA.    THE  ,                    TX100450
     236H  REQUIREMENTS.  THE WEIGHTS COVERED/                            TX100460
     31X,36HRESULTS  ARE  PRESENTED IN SEVERAL  ,                         TX100470
     436H  BY THIS REPORT, TOGETHER WITH  THE/                            TX100480
     51X,36HFORMATS.   ASSIGNED  MASS  VALUES,  ,                         TX100490
     636H  ASSIGNED  VALUES  AND  THE  APPRO-/                            TX100500
     71X,36HDISPLACEMENT VOLUMES, COEFFICIENTS  ,                         TX100510
     836H  PRIATE  UNCERTAINTIES  FOR  THESE/                             TX100520
     91X,36HOF  EXPANSION,  UNCERTAINTIES,  TO-  ,                        TX100530
     *36H  VALUES,  PROVIDE  IN  PART A BASIS)                            TX100540
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50    FORMAT (1X,36HGETHER WITH THE SUMMED VALUES  FOR  ,                TX100550
     236H  FOR CONSISTENT MEASUREMENTS WITHIN/                           TX100560
     31X,36HLINEAR COMBINATIONS OF THE WEIGHTS  ,                        TX100570
     436H  THIS SYSTEM OF RELATED MEASUREMENT/                           TX100580
     51X,36H-IN  EACH  DECADE  ARE PRESENTED AT  ,                       TX100590
     636H  PROCESSES.                           /                        TX100600
     71X,36HTHE END OF THE APPROPRIATE SERIES.  ,                        TX100610
     836H                                       /                        TX100620
     91X,36HTHIS INFORMATION SHOULD BE  USEFUL  ,                        TX100630
     *36H      APPROPRIATE   CHARACTERIZATION)                           TX100640
60    FORMAT (1X,36HTO  THOSE  WHO  MUST  ASSIGN  MASS  ,                TX100650
     236H  OF   ANY  MEASUREMENT  PROCESS  IS/                           TX100660
     31X,36HVALUES  TO  OBJECTS  OTHER  THAN  ,                          TX100670
     436H  FUNDAMENTAL  TO  VERIFYING  THAT/                             TX100680
     51X,36HWEIGHTS.    FOR CONVENIENCE,  THE  ,                         TX100690
     636H  RESULTS  ARE  CONSISTENT  WITH THE/                           TX100700
     71X,36HVALUES AND UNCERTAINTIES, TOGETHER  ,                        TX100710
     836H  END REQUIREMENT  WITH  RESPECT  TO/                           TX100720
     91X,36HWITH OTHER  APPROPRIATE  DATA  AND  ,                        TX100730
     *36H  CORRECTNESS  AND  ECONOMY  OF  THE)                           TX100740
70    FORMAT (1X,36HCOMMENTS  ARE  ALSO  SUMMARIZED  IN  ,               TX100750
     236H  MEASUREMENT EFFORT.  WITHOUT  THIS/                           TX100760
     31X,36HTABLES I AND II AT THE END OF  THE  ,                        TX100770
     436H  INFORMATION.   THE  BENEFITS  OF/                             TX100780
     51X,36H-REPORT.     CERTAIN  INTERMEDIATE  ,                        TX100790
     636H  OWNERSHIP OF THESE WEIGHTS MAY  BE/                           TX100800
     71X,36HPAGES ARE SUMMARIES OF STATISTICAL  ,                        TX100810
     836H  COMPLETELY ILLUSORY.  THE ASSIGNED/                           TX100820
     91X,36HDATA  WHICH  RELATE  TO  THE  MASS  ,                        TX100830
     *36H  UNCERTAINTIES  IN  THIS REPORT ARE)                           TX100840
80    FORMAT (1X,36HMEASUREMENT    PROCESS    USED    TO  ,              TX100850
     236H  DESCRIPTIVE OF OUR  MASS  MEASURE-/                           TX100860
     31X,36H-PERFORM THIS  WORK.   THESE  PAGES  ,                       TX100870
     436H  MENT  PROCESS.   EFFECTIVENESS  OF/                           TX100880
     51X,36HHAVE  BEEN  LEFT  IN THE REPORT TO  ,                        TX100890
     636H  THE TRANSFER OF THE UNIT FROM  ONE/                           TX100900
     71X,36HRETAIN  CONTINUITY.    COPIES  OF  ,                         TX100910
     836H  FACILITY  TO  ANOTHER  SHOULD  BE/                            TX100920
     91X,36HTHESE   PAGES  BECOME  PART  OF  A  ,                        TX100930
     *36H  VERIFIED BY AN  INDEPENDENT  TEST.)                           TX100940
90    FORMAT (1X,36HCOLLECTION  OF  STATISTICAL  DATA  ,                 TX100950
     236H  IT  IS PRESUMED THAT THESE WEIGHTS/                           TX100960
     31X,36HWHICH  REFLECTS  THE  MEASUREMENT  ,                         TX100970
     436H  WILL BE USED IN A SIMILARLY  WELL-/                           TX100980
     51X,36HPROCESS PERFORMANCE OVER A  PERIOD  ,                        TX100990
     636H  CHARACTERIZED MEASUREMENT  PROCESS/                           TX101000
     71X,36HOF  TIME.   SUCH  A  COLLECTION HAS  ,                       TX101010
     836H  SO THAT THE STATISTICAL PARAMETERS/                           TX101020
     91X,36HBEEN USED TO ESTABLISH THE CONTROL  ,                        TX101030
     *36H  OF  BOTH PROCESSES CAN BE COMBINED)                           TX101040
100   FORMAT (1X,36HLIMITS FOR ACCEPTING  THE  RESULTS  ,                TX101050
     236H  TO PROVIDE A REALISTIC ESTIMATE OF/                           TX101060
     31X,36HOF  THIS  MEASUREMENT.  THESE COL-  ,                        TX101070
     436H  THE UNCERTAINTY OF THE  MASS  UNIT/                           TX101080
     51X,36HLECTIONS ARE OPEN  FOR  INSPECTION  ,                        TX101090
     636H  AS  ACTUALLY  REALIZED  IN ANOTHER/                           TX101100
     71X,36HAT OUR FACILITY.                    ,                        TX101110
     836H  FACILITY.  A COMPREHENSIVE SERVICE/                           TX101120
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     91X,36H                                          ,                    TX101130
     *36H  DIRECTED TOWARD THE EVALUATION  OF)                              TX101140
110   FORMAT (1X,36H   THE MASS MEASUREMENT SYSTEM       ,                  TX101150
     236H  A   PARTICULAR   MASS  MEASUREMENT/                              TX101160
     31X,36H                                          ,                    TX101170
     436H  PROCESS IS AVAILABLE  THROUGH  THE/                              TX101180
     51X,36H    THE  MASS  MEASUREMENT  SYSTEM  ,                           TX101190
     636H  MASS MEASUREMENT ASSURANCE PROGRAM/                              TX101200
     71X,36HWITHIN THIS  COUNTRY  CONSISTS  OF  ,                           TX101210
     836H  OF   THE   NATIONAL   BUREAU    OF/                              TX101220
     91X,36HALL  OF  THE MEASUREMENT PROCESSES  ,                           TX101230
     *36H  STANDARDS.                          )                            TX101240
      END                                                                   TX101250
--- TEXT2 SUBPROGRAM ---
      SUBROUTINE TEXT2                                                      TX200010
C*************************************************************************TX200020
C**   SUBROUTINE OF THE NATIONAL BUREAU OF STANDARDS MASS CALIBRATION **TX200030
C**   PROGRAM  VERSION OF SEPT. 10,1971    WRITTEN BY R.C.RAYBOLD     **TX200040
C**   AND MRS.R.N.VARNER                                              **TX200050
C**   MODIFIED BY R. N. VARNER SEPT 1979                              **TX200060
C*************************************************************************TX200070
      COMMON/UNITIO/IR,IW,IP,IPL,ITMP                                       TX200080
      WRITE (IW,10)                                                         TX200090
      WRITE (IW,20)                                                         TX200100
      WRITE (IW,30)                                                         TX200110
      WRITE (IW,40)                                                         TX200120
      WRITE (IW,50)                                                         TX200130
      WRITE (IW,60)                                                         TX200140
      WRITE (IW,70)                                                         TX200150
      WRITE (IW,80)                                                         TX200160
      WRITE (IW,90)                                                         TX200170
      WRITE (IW,100)                                                        TX200180
      WRITE (IW,110)                                                        TX200190
      RETURN                                                                TX200200
C*************************************************************************TX200210
C**   FORMAT STATEMENTS                                               **TX200220
C*************************************************************************TX200230
10    FORMAT (/)                                                            TX200240
20    FORMAT (1X,36H          WEIGHING DESIGN            ,                  TX200250
     236H  STANDARD  IS  MEASURED  WITH  EACH/                              TX200260
     31X,36H                                          ,                    TX200270
     436H  TEST OF UNKNOWNS AND  THE  COLLEC-/                              TX200280
     51X,36H    ONLY  DIFFERENCES  IN MASS CAN  ,                           TX200290
     636H  TION  OF  VALUES OVER TIME IS USED/                              TX200300
     71X,36HBE MEASURED,  THEREFORE  THE  MASS  ,                           TX200310
     836H  TO EVALUATE THE PERFORMANCE OF THE/                              TX200320
     91X,36HVALUES  FOR  THE 'UNKNOWN' WEIGHTS  ,                           TX200330
     *36H  MEASUREMENT PROCESS.                )                            TX200340
30    FORMAT (1X,36HMUST BE DETERMINED  BY  COMPARISON  ,                    TX200350
     236H                                      /                           TX200360
     31X,36HWITH   OTHER  WEIGHTS  WHICH  HAVE  ,                           TX200370
     436H      IN  THE  CASE  OF  THE  SERIES/                              TX200380
     51X,36HACCEPTED   MASS    VALUES.     THE  ,                           TX200390
     636H  WHICH  INCLUDES  THE  KNOWN STAND-/                              TX200400
     71X,36H'UNKNOWN'  WEIGHTS  TOGETHER  WITH  ,                           TX200410
     836H  ARDS. THE ACCEPTED VALUES OF THESE/                              TX200420
     91X,36H'CHECK STANDARDS', ARE GROUPED AND  ,                           TX200430
     *36H  STANDARDS SERVE AS A RESTRAINT  ON)                              TX200440
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40    FORMAT (1X,36HINTERCOMPARED ACCORDING TO   THE ,                TX200450
     236H  THE  SOLUTION OF THE EQUATIONS FOR/                        TX200460
     31X,36HDESIGN  SCHEDULE  GIVEN AT THE BE- ,                      TX200470
     436H  THE VALUES OF ALL OF THE  WEIGHTS./                        TX200480
     51X,36HGINNING OF EACH SERIES  OF  WEIGH- ,                      TX200490
     636H  THE  RESTRAINT FOR THE SOLUTION OF/                        TX200500
     71X,36HINGS.   THE  FIRST SERIES CONTAINS ,                      TX200510
     836H  SUBSEQUENT SERIES IS  PROVIDED  BY/                        TX200520
     91X,36HSTANDARDS   WHICH   PROVIDE    THE ,                      TX200530
     *36H  THE  VALUES ESTABLISHED FOR ONE OR)                        TX200540
50    FORMAT (1X,36HSTARTING  VALUES FOR THE SERIES OF ,               TX200550
     236H  MORE   WEIGHTS   INCLUDED   IN   A/                        TX200560
     31X,36HWEIGHINGS AND  PROVIDE  THE  TIE ,                        TX200570
     436H  PREVIOUS SERIES.                  /                        TX200580
     51X,36HPOINT  FOR  CONSISTENCY THROUGHOUT ,                      TX200590
     636H                                    /                        TX200600
     71X,36HTHE   MEASUREMENT   SYSTEM.    THE ,                      TX200610
     836H       ESTIMATED  VALUES  FOR WEIGHTS/                       TX200620
     91X,36HWEIGHING METHOD USED, I.E., DOUBLE ,                      TX200630
     *36H  WHICH HAVE  BEEN  GROUPED  IN  THE)                        TX200640
60    FORMAT (1X,36HSUBSTITUTION, TRANSPOSITION, ETC.,  ,              TX200650
     236H  SAME   SERIES   INVOLVE  THE  SAME/                        TX200660
     31X,36HIS   INDICATED   ALONG   WITH   THE ,                     TX200670
     436H  OBSERVATIONAL  DATA  AND  ARE,  IN/                        TX200680
     51X,36HOBSERVED DATA.   IN  THE  COMPUTA- ,                      TX200690
     636H  ALMOST ALL CASES, CORRELATED.  FOR/                        TX200700
     71X,36HTIONS,  THE  DISPLACEMENT  VOLUMES ,                      TX200710
     836H  EACH  SERIES  THERE  IS  A TABLE OF/                       TX200720
     91X,36HARE TREATED EXPLICITLY, USING  THE ,                      TX200730
     *36H  COMBINATIONS  TOGETHER  WITH   THE)                        TX200740
70    FORMAT (1X,36HDATA LISTED IN THE REPORT.  IN ALL ,               TX200750
     236H  APPROPRIATE  UNCERTAINTY  FOR EACH/                        TX200760
     31X,36HCASES.  A REDUNDANCY IN THE NUMBER ,                      TX200770
     436H  COMBINATION.                      /                        TX200780
     51X,36HOF MEASUREMENTS PROVIDES  A  MEANS ,                      TX200790
     636H                                    /                        TX200800
     71X,36HFOR  CHECKING  ON THE PRECISION OF ,                      TX200810
     836H            PROCESS CONTROL         /                        TX200820
     91X,36HTHE PROCESS.                     ,                        TX200830
     *36H                                    )                        TX200840
80    FORMAT (1X,36H                                  ,               TX200850
     236H       THE  STANDARD  DEVIATION,   AS/                       TX200860
     31X,36H   WHEN THERE ARE MORE  EQUATIONS ,                       TX200870
     436H  COMPUTED  FROM  THE  LEAST SQUARES/                        TX200880
     51X,36HTHAN 'UNKNOWNS', NOT ALL OBSERVA- ,                       TX200890
     636H  SOLUTION, PROVIDES A CHECK ON  THE/                        TX200900
     71X,36HTIONAL EQUATIONS CAN BE  SATISFIED ,                      TX200910
     836H  SHORT  TERM,  OR 'WITHIN-RUN' PRO-/                        TX200920
     91X,36HEXACTLY  AND  THE  METHOD OF LEAST ,                      TX200930
     *36H  CESS PRECISION.  AN AVERAGE  OF  A)                        TX200940
90    FORMAT (1X,36HSQUARES   IS   USED   TO   PROVIDE ,               TX200950
     236H  NUMBER  OF  THESE  STANDARD DEVIA-/                        TX200960
     31X,36HESTIMATES OF THE 'UNKNOWN' VALUES. ,                      TX200970
     436H  TIONS IS  TAKEN  AS  THE  ACCEPTED/                        TX200980
     51X,36HTHIS  METHOD  LEADS  TO ESTIMATORS ,                      TX200990
     636H  WITHIN-RUN  STANDARD  DEVIATION OF/                        TX201000
     71X,36HWHICH ARE LINEAR FUNCTIONS OF  THE ,                      TX201010
     836H  THE  PROCESS  AND  IS  USED  AS  A/                        TX201020
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     91X,36HDATA   AND   WHICH  HAVE  STANDARD  ,                    TX201030
     *36H  REFERENCE  VALUE  FOR SURVEILLANCE)                       TX201040
100   FORMAT (1X,36HDEVIATIONS READILY CALCULATED FROM  ,            TX201050
     236H  OF  THE  PROCESS  PRECISION.   THE/                       TX201060
     31X,36HTHE  COEFFICIENTS  OF  THE  LINEAR  ,                    TX201070
     436H  VALUES  OBTAINED  FOR  THE  'CHECK/                       TX201080
     51X,36HFUNCTIONS  AND THE STANDARD DEVIA-  ,                    TX201090
     636H  STANDARD' PROVIDE,  AS  TIME  GOES/                       TX201100
     71X,36HTION OF AN INDIVIDUAL MEASUREMENT.  ,                    TX201110
     836H  ON,  A  SEQUENCE  OF  VALUES  THAT/                       TX201120
     91X,36HTHE  'CHECK  STANDARD'   IS   ALSO  ,                    TX201130
     *36H  REALISTICALLY     REFLECTS     THE)                       TX201140
110   FORMAT (1X,36HTREATED  AS  AN  UNKNOWN  AND  THE  ,            TX201150
     236H  VARIATIONS   WHICH  BESET  PRECISE/                       TX201160
     31X,36HAGREEMENT  OF  THE  CURRENT  RESULT  ,                   TX201170
     436H  MEASUREMENTS.    COLLECTIONS    OF/                       TX201180
     51X,36HWITH THE ACCEPTED VALUE PROVIDES A  ,                    TX201190
     636H  VALUES  FOR  BOTH  THE  WITHIN-RUN/                       TX201200
     71X,36HTEST  OF  THE ADEQUACY OF THE CUR-  ,                    TX201210
     836H  PRECISION AND THE  VALUE  OBTAINED/                       TX201220
     91X,36HRENT  DATA.    THIS   SAME   CHECK  ,                    TX201230
     *36H  FOR  THE  'CHECK  STANDARD' SHOULD)                       TX201240
      END                                                            TX201250
--- TEXT3 SUBPROGRAM ---
      SUBROUTINE TEXT3                                               TX300010
C*************************************************************************TX300020
C**   SUBROUTINE OF THE NATIONAL BUREAU OF STANDARDS MASS CALIBRATION **TX300030
C**   PROGRAM  VERSION OF SEPT. 10,1971    WRITTEN BY R.C.RAYBOLD     **TX300040
C**   AND MRS.R.N.VARNER                                             **TX300050
C**   MODIFIED BY R. N. VARNER SEPT 1979                             **TX300060
C*************************************************************************TX300070
      COMMON/UNITIO/IR,IW,IP,IPL,ITMP                                TX300080
      WRITE (IW,10)                                                  TX300090
      WRITE (IW,20)                                                  TX300100
      WRITE (IW,30)                                                  TX300110
      WRITE (IW,40)                                                  TX300120
      WRITE (IW,50)                                                  TX300130
      WRITE (IW,60)                                                  TX300140
      WRITE (IW,70)                                                  TX300150
      WRITE (IW,80)                                                  TX300160
      WRITE (IW,90)                                                  TX300170
      WRITE (IW,100)                                                 TX300180
      WRITE (IW,110)                                                 TX300190
      RETURN                                                         TX300200
C*************************************************************************TX300210
C**  FORMAT STATEMENTS                                              **TX300220
C*************************************************************************TX300230
10    FORMAT (/)                                                     TX300240
20    FORMAT (1X,36HPOSSESS THE PROPERTIES OF  RANDOM-  ,            TX300250
     236H       SERIES OF MEASUREMENTS  JUDGED/                     TX300260
     31X,36HNESS  ASSOCIATED  WITH  INDEPENDENT  ,                   TX300270
     436H  AS  OUT OF CONTROL RELATIVE TO THE/                       TX300280
     51X,36HMEASUREMENTS   FROM    A    STABLE  ,                    TX300290
     636H  APPROPRIATE  PARAMETER  ARE  CARE-/                       TX300300
     71X,36HPROBABILITY   DISTRIBUTION.    THE  ,                    TX300310
     836H  FULLY  EXAMINED.   IF  RERUNS  WERE/                      TX300320
     91X,36HREPORTED 'F RATIO' AND  'T  VALUE'  ,                    TX300330
     *36H  NECESSARY IN THE  COURSE  OF  THIS)                       TX300340
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30    FORMAT (1X,36HARE  TESTS  OF THE VALUES FROM THE  ,                TX300350
     236H  WORK, THE 'OUT OF CONTROL' SERIES,/                           TX300360
     31X,36HCURRENT  RUN  FOR  CONFORMITY  TO  ,                         TX300370
     436H  WITH  REMARKS  AS APPROPRIATE, ARE/                           TX300380
     51X,36HTHEIR RESPECTIVE DISTRIBUTIONS AND  ,                        TX300390
     636H  ATTACHED AT THE END OF THE  REPORT/                           TX300400
     71X,36HIF   SATISFACTORY   ARE  TAKEN  AS  ,                        TX300410
     836H  FOR YOUR INFORMATION.              /                          TX300420
     91X,36HEVIDENCE THAT THE  PROCESS  IS  IN  ,                        TX300430
     *36H                                     )                          TX300440
40    FORMAT (1X,36HCONTROL    AND    THAT    PREDICTIVE  ,              TX300450
     236H              UNCERTAINTY            /                          TX300460
     31X,36HSTATEMENTS  REGARDING  UNCERTAINTY  ,                        TX300470
     436H                                     /                          TX300480
     51X,36HARE VALID.                          ,                       TX300490
     636H       IT IS ASSUMED THAT THE PRESENT/                          TX300500
     71X,36H                                    ,                       TX300510
     836H  'ACCEPTED VALUES' OF TWO NBS STAN-/                           TX300520
     91X,36H    CONTROL  CHARTS ON THE WITHIN-  ,                        TX300530
     *36H  DARDS  AT  THE  1  KILOGRAM LEVEL,)                           TX300540
50    FORMAT (1X,36HRUN  PROCESS  PRECISION  AND  THE  ,                 TX300550
     236H  DESIGNATED N1 AND N2, ARE  WITHOUT/                           TX300560
     31X,36HVALUES   OBTAINED  FOR  THE  CHECK  ,                        TX300570
     436H  ERROR.   ESTIMATES  OF  THE UNCER-/                           TX300580
     51X,36HSTANDARD  ARE  KEY   ELEMENTS   IN  ,                        TX300590
     636H  TAINTY OF THE ACCEPTED  VALUES  OF/                           TX300600
     71X,36HMONITORING THE STATE OF CONTROL OF  ,                        TX300610
     836H  THE NBS STANDARDS RELATIVE TO  THE/                           TX300620
     91X,36HANY   PRECISE   MASS   MEASUREMENT  ,                        TX300630
     *36H  INTERNATIONAL  PROTOTYPE  KILOGRAM)                           TX300640
60    FORMAT (1X,36HPROCESS.  IN ADDITION TO PROVIDING  ,                TX300650
     236H  CAN  BE   PROVIDED   ON   REQUEST./                           TX300660
     31X,36HA BASIS FOR  JUDGMENT  AS  TO  THE  ,                        TX300670
     436H  HOWEVER,  THESE  ESTIMATES HAVE NO/                           TX300680
     51X,36HADEQUACY  OF A GIVEN PROCESS FOR A  ,                        TX300690
     636H  REAL MEANING IN EITHER NATIONAL OR/                           TX300700
     71X,36HPARTICULAR REQUIREMENT. THESE DATA  ,                        TX300710
     836H  INTERNATIONAL COMPARISON.  THIS IS/                           TX300720
     91X,36HPROVIDE  A  MEANS  TO  JUDGE  THE  ,                         TX300730
     *36H  BECAUSE OF THE LACK OF  SUFFICIENT)                           TX300740
70    FORMAT (1X,36HIMPORTANCE   OF   LONG   TERM,  OR  ,                TX300750
     236H  DATA   TO   PROVIDE   A  REALISTIC/                           TX300760
     31X,36H'BETWEEN-RUN'  VARIABILITY  WHICH  ,                         TX300770
     436H  ESTIMATE OF THE UNCERTAINTY IN THE/                           TX300780
     51X,36HCAN   BE   CHARACTERIZED   BY  THE  ,                        TX300790
     636H  VALUES ASSIGNED TO  THE  PROTOTYPE/                           TX300800
     71X,36HSTANDARD DEVIATION OF  THE  VALUES  ,                        TX300810
     836H  KILOGRAMS K20 AND K4, PARTICULARLY/                           TX300820
     91X,36HABOUT  THE  MEAN.   IF THERE IS AN  ,                        TX300830
     *36H  IN   REGARD   TO   LONG  TERM,  OR)                           TX300840
80    FORMAT (1X,36HADDITIONAL COMPONENT  OF  VARIANCE  ,                TX300850
     236H  BETWEEN-RUN VARIABILITY.   CHANGES/                           TX300860
     31X,36HENTERING  FROM  RUN  TO  RUN,  THIS  ,                       TX300870
     436H  IN THE ACCEPTED VALUES FOR THE NBS/                           TX300880
     51X,36HSTANDARD DEVIATION WILL BE  LARGER  ,                        TX300890
     636H  STANDARDS  AT  THE KILOGRAM LEVEL,/                           TX300900
     71X,36HTHAN  CAN  BE ACCOUNTED FOR BY THE  ,                        TX300910
     836H  AS AND WHEN THEY  OCCUR,  WILL  BE/                           TX300920
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     91X,36HWITHIN-RUN VARIABILITY,  CORRELA-  ,                    TX300930
     *36H  REPORTED  IN THE SCIENTIFIC PAPERS)                       TX300940
90    FORMAT (1X,36HTION  STUDIES,  AS WELL AS SUPPLE-  ,            TX300950
     236H  OF THE BUREAU AND  WILL  BE  GIVEN/                       TX300960
     31X,36HMENTAL EXPERIMENTS,  ARE  USED  TO  ,                    TX300970
     436H  WIDE DISTRIBUTION.  IN CASES WHERE/                       TX300980
     51X,36HDETECT AND REDUCE THE MAGNITUDE OF  ,                    TX300990
     636H  SUCH CHANGES MAY BE OF IMPORTANCE,/                       TX301000
     71X,36HSIGNIFICANT  SYSTEMATIC  EFFECTS.  ,                     TX301010
     836H  OR  WHERE  CONTINUITY  IS DESIRED,/                       TX301020
     91X,36HAPPROPRIATE  ACTION,  E.G.,  ADDI-  ,                    TX301030
     *36H  INSTRUCTIONS WILL BE INCLUDED  FOR)                       TX301040
100   FORMAT (1X,36HTIONAL  EMPIRICAL  CORRECTIONS  OR  ,            TX301050
     236H  UP-DATING  PREVIOUSLY  REPORTED/                          TX301060
     31X,36HCHANGES IN TECHNIQUE,  CAN  REDUCE  ,                    TX301070
     436H  VALUES.  WHEN THE VALUES  REPORTED/                       TX301080
     51X,36HTHE  EFFECTS FROM KNOWN SOURCES OF  ,                    TX301090
     636H  ARE  EASED  ON THE ACCEPTED VALUES/                       TX301100
     71X,36HSYSTEMATIC  VARIABILITY  TO  A  ,                        TX301110
     836H  OF STANDARDS OTHER THAN  STANDARDS/                       TX301120
     91X,36HMAGNITUDE  WHICH  IS  NO  LONGER  ,                      TX301130
     *36H  N1  AND  N2  MENTIONED  ABOVE,  THE)                      TX301140
110   FORMAT (1X,36HIDENTIFIABLE IN THE DATA.  IN  THE  ,            TX301150
     236H  UNCERTAINTY OF THE ACCEPTED  VALUE/                       TX301160
     31X,36HCASES  WHERE  A  SIGNIFICANT  LONG  ,                    TX301170
     436H  OF  THE  STANDARD  BECOMES  A/                            TX301180
     51X,36HTERM,  OR  BETWEEN-RUN,  COMPONENT  ,                    TX301190
     636H  SYSTEMATIC ERROR IN THE ASSIGNMENT/                       TX301200
     71X,36HREMAINS  THE  UNCERTAINTY HAS BEEN  ,                    TX301210
     836H  OF VALUES TO OTHER  STANDARDS  AND/                       TX301220
     91X,36HAPPROPRIATELY ADJUSTED.  ,                               TX301230
     *36H  IS INCLUDED IN THE REPORT.  )                             TX301240
      END                                                            TX301250
--- TEXT4 SUBPROGRAM ---
      SUBROUTINE TEXT4                                               TX400010
C*****************************************************************TX400020
C**   SUBROUTINE OF THE NATIONAL BUREAU OF STANDARDS MASS CALIBRATION **TX400030
C**   PROGRAM  VERSION OF SEPT. 10,1971    WRITTEN BY R.C.RAYBOLD     **TX400040
C**   AND MRS.R.N.VARNER                                             **TX400050
C**   MODIFIED BY R. N. VARNER SEPT 1979                             **TX400060
C*****************************************************************TX400070
      COMMON/UNITIO/IR,IW,IP,IPL,ITMF                                TX400080
      WRITE (IW,10)                                                  TX400090
      WRITE (IW,20)                                                  TX400100
      WRITE (IW,30)                                                  TX400110
      WRITE (IW,40)                                                  TX400120
      WRITE (IW,50)                                                  TX400130
      WRITE (IW,60)                                                  TX400140
      WRITE (IW,70)                                                  TX400150
      WRITE (IW,80)                                                  TX400160
      WRITE (IW,90)                                                  TX400170
      WRITE (IW,100)                                                 TX400180
      WRITE (IW,110)                                                 TX400190
      RETURN                                                         TX400200
C*****************************************************************TX400210
C**   FORMAT STATEMENTS                                            **TX400220
C*****************************************************************TX400230
10    FORMAT (/)                                                     TX400240
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20    FORMAT (1X,36H    A  BALANCE UNDER STABLE OPERA-  ,                TX400250
     236H  SHOULD ALMOST ALWAYS OVERLAP.   IN/                           TX400260
     31X,36HTING  CONDITIONS  WILL  EXHIBIT  A  ,                        TX400270
     436H  OTHER WORDS, WHILE A SECOND MEA-/                             TX400280
     51X,36HCERTAIN CHARACTERISTIC VARIABILITY  ,                        TX400290
     636H  SUREMENT WILL PRODUCE A DIFFERENT/                            TX400300
     71X,36HWHICH  CAN  BE  DESCRIBED  BY  THE  ,                        TX400310
     836H  VALUE, THIS VALUE WILL ONLY RARELY/                           TX400320
     91X,36HSTANDARD  DEVIATION  FOR  SUCH  ,                            TX400330
     *36H  DIFFER FROM  THE  FIRST  VALUE  BY)                           TX400340
30    FORMAT (1X,36HMEASUREMENTS.   THE  VALUE  FOR  A  ,                TX400350
     236H  MORE  THAN  THE  SUM  OF  THE  TWO/                           TX400360
     31X,36HPARTICULAR  WEIGHT  DETERMINED  IN  ,                        TX400370
     436H  UNCERTAINTIES.    THE  UNCERTAINTY/                           TX400380
     51X,36HREPEATED  TESTS  WITH  THE  SAME  ,                          TX400390
     636H  BANDS ARE NOT EXPECTED TO  OVERLAP/                           TX400400
     71X,36HWEIGHING  DESIGN  WILL  HAVE  ITS  OWN  ,                    TX400410
     836H  IF SOME EVENT HAS OCCURRED IN  THE/                           TX400420
     91X,36HSTANDARD  DEVIATION  WHICH  WILL  BE  ,                      TX400430
     *36H  TIME INTERVAL BETWEEN THE TWO MEA-)                           TX400440
40    FORMAT (1X,36HSOME  FUNCTION  OF  THE  BALANCE  ,                  TX400450
     236H  SUREMENTS WHICH  WILL  CHANGE  THE/                           TX400460
     31X,36HPRECISION  AND  (POSSIBLY)  OF  THE  ,                       TX400470
     436H  MASS OF THE OBJECT.  E.G.,   ABRA-/                           TX400480
     51X,36HBETWEEN-RUN  COMPONENT.    AS  AN  ,                         TX400490
     636H  SIONS, ABUSE, CORROSION, IMPROPER/                            TX400500
     71X,36HOUTER LIMIT OF THE DISTRIBUTION OF  ,                        TX400510
     836H  CLEANING AND THE LIKE.              /                         TX400520
     91X,36HRANDOM  ERRORS,  THREE  TIMES  THE  ,                        TX400530
     *36H                                      )                         TX400540
50    FORMAT (1X,36HSTANDARD  DEVIATION  IS  USED.  ,                    TX400550
     236H      THE UNCERTAINTY IN ASSIGNED/                              TX400560
     31X,36HSYSTEMATIC  ERRORS  DUE  TO  THE  ,                          TX400570
     436H  VALUE CONTAINED IN THIS REPORT/                               TX400580
     51X,36HPROCEDURES  USED  OR  TO  ENVIRON-  ,                        TX400590
     636H  BECOMES A SYSTEMATIC EFFECT FOR/                              TX400600
     71X,36HMENTAL  EFFECTS  ARE  LARGELY  ,                             TX400610
     836H  THE MEASUREMENT PROCESS IN WHICH/                             TX400620
     91X,36HBALANCED CUT AND  CAN  USUALLY  BE  ,                        TX400630
     *36H  THESE WEIGHTS ARE TO BE USED.   IN)                           TX400640
60    FORMAT (1X,36HREGARDED  AS  NEGLIGIBLE.   WHEN  A  ,               TX400650
     236H  THE ABSENCE OF OTHER SIGNIFICANT/                             TX400660
     31X,36HNON-NEGLIGIBLE  ECUND  TO  THE  ,                            TX400670
     436H  SYSTEMATIC EFFECTS IN THE USER'S/                             TX400680
     51X,36HPOSSIBLE EFFECT FROM KNOWN SOURCES  ,                        TX400690
     636H  MEASUREMENT  PROCESS  (A CONDITION/                           TX400700
     71X,36HIS AVAILABLE, IT IS CALCULATED AND  ,                        TX400710
     836H  WHICH MUST  BE  DEMONSTRATED)  THE/                           TX400720
     91X,36HREPORTED  SEPARATELY.  E.G.,  THE  ,                         TX400730
     *36H  UNCERTAINTY  OF THE VALUE ASSIGNED)                           TX400740
70    FORMAT (1X,36HUNCERTAINTY OF ACCEPTED  VALUE  AT  ,                TX400750
     236H  BY  THE  USER  IS  AN  APPROPRIATE/                           TX400760
     31X,36HOTHER  THAN  THE  1 KILOGRAM LEVEL.  ,                       TX400770
     436H  COMBINATION  OF  THE  SYSTEMATIC/                             TX400780
     51X,36HTHE DISTRIBUTION  IMPLIED  BY  THE  ,                        TX400790
     636H  ERROR  IN  THE  STANDARD  AND  THE/                           TX400800
     71X,36HRANDOM ERRORS MAY THUS BE CENTERED  ,                        TX400810
     836H  RANDOM  COMPONENT  ASSOCIATED  WITH/                          TX400820
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     91X,36HSOMEWHERE  IN  THE  RANGE GIVEN BY  ,                      TX400830
     *36H  HIS PROCESS.  IF  THE  MEASUREMENT)                         TX400840
80    FORMAT (1X,36HTHE  BOUNDS  TO   THE   SYSTEMATIC  ,              TX400850
     236H  PROCESSES   ARE   IN  CONTROL  AND/                         TX400860
     31X,36HERROR.   THE  TOTAL UNCERTAINTY IS  ,                      TX400870
     436H  APPROPRIATE   UNCERTAINTIES    ARE/                         TX400880
     51X,36HTAKEN AS  THE  SUM  OF  THESE  TWO  ,                      TX400890
     636H  ASSIGNED,  THE  VALUES PRODUCED BY/                         TX400900
     71X,36HCOMPONENTS.                         ,                      TX400910
     836H  DIFFERENT  MEASUREMENT  FACILITIES/                         TX400920
     91X,36H                                    ,                      TX400930
     *36H  WILL  HAVE OVERLAPPING UNCERTAINTY)                         TX400940
90    FORMAT (1X,36H    THE   UNCERTAINTY   ASSOCIATED  ,               TX400950
     236H  BANDS  AS  DESCRIBED  ABOVE.   ONE/                         TX400960
     31X,36HWITH THE  ASSIGNED  VALUE  CAN  BE  ,                      TX400970
     436H  CANNOT   DISCUSS   DIFFERENCES  IN/                         TX400980
     51X,36HTHOUGHT  OF  AS  A  BOUND  TO  THE  ,                      TX400990
     636H  VALUES   FOR   THE   SAME   OBJECT/                         TX401000
     71X,36HDEPARTURE OF  THE  ASSIGNED  VALUE  ,                      TX401010
     836H  OBTAINED  BY  DIFFERENT FACILITIES/                         TX401020
     91X,36HFROM  A HYPOTHETICAL AVERAGE VALUE  ,                      TX401030
     *36H  WITH ANY DEGREE OF SERIOUSNESS UN-)                         TX401040
100   FORMAT (1X,36HTHAT WOULD BE OBTAINED IF IT  WERE  ,              TX401050
     236H  LESS EACH VALUE IS ACCOMPANIED  BY/                         TX401060
     31X,36HPOSSIBLE TO REPEAT THE MEASUREMENT  ,                      TX401070
     436H  A REALISTIC UNCERTAINTY STATEMENT./                         TX401080
     51X,36HMANY  TIMES OVER A WIDE VARIETY OF  ,                      TX401090
     636H                                       /                      TX401100
     71X,36HCONDITIONS, E.G.,  SUBSTITUTE  THE  ,                      TX401110
     836H                                       /                      TX401120
     91X,36HWEIGHT   FOR   ONE  OF  THE  CHECK  ,                      TX401130
     *36H                                       )                      TX401140
110   FORMAT (1X,36HSTANDARDS.   THIS  MEANS THAT  THE  ,              TX401150
     236H                                       /                      TX401160
     31X,36HUNCERTAINTY BAND  CENTERED  ON THE  ,                      TX401170
     436H                                       /                      TX401180
     51X,36HVALUES OBTAINED FROM EACH  OF  TWO  ,                      TX401190
     636H                                       /                      TX401200
     71X,36HMEASUREMENTS OF  THE  SAME  OBJECT  ,                      TX401210
     836H                                       /                      TX401220
     91X,36HOVER SOME ARBITRARY TIME  INTERVAL  ,                      TX401230
     *36H                                       )                      TX401240
      END                                                              TX401250
--- TEXTS SUBPROGRAM ---
      SUBROUTINE TEXTS                                                 TX500010
C*****************************************************************TX500020
C**   SUBROUTINE OF THE NATIONAL BUREAU OF STANDARDS MASS CALIBRATION **TX500030
C**   PROGRAM VERSION OF SEPT. 10, 1971   WRITTEN BY R.C. RAYFIELD     **TX500040
C**   AND MRS.F.N.VARNER                                             **TX500050
C**   MODIFIED BY R. N. VARNER SEPT 1977                             **TX500060
C*****************************************************************TX500070
      COMMON/UNITIO/IR,IW,IP,IPL,ITMP                                  TX500080
      WRITE (IW,10)                                                    TX500090
      WRITE (IW,20)                                                    TX500100
      WRITE (IW,30)                                                    TX500110
      WRITE (IW,40)                                                    TX500120
      WRITE (IW,50)                                                    TX500130
      WRITE (IW,60)                                                    TX500140
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      WRITE (IW,70)                                                    TX500150
      WRITE (IW,80)                                                    TX500160
      WRITE (IW,90)                                                    TX500170
      WRITE (IW,100)                                                   TX500180
      WRITE (IW,110)                                                   TX500190
      RETURN                                                           TX500200
C*****************************************************************TX500210
C**   FORMAT STATEMENTS                                          **TX500220
C*****************************************************************TX500230
10    FORMAT (1X,36H                                    ,             TX500240
     236H                                        )                   TX500250
20    FORMAT (1X,36H                                     REFERENCES,  TX500260
     236H                                       /                    TX500270
     31X,36H                                      ,                   TX500280
     436H                                       /                    TX500290
     51X,36HTHE FOLLOWING REFERENCES ARE SUGGEST,                     TX500300
     636HED FOR DETAILED DESCRIPTION OF         /                    TX500310
     71X,36HPORTIONS OF THIS REPORT , AND FOR GE,                     TX500320
     836HNERAL INFORMATION CONCERNING THE       /                    TX500330
     91X,36HMASS MEASUREMENT PROCESS:             ,                  TX500340
     *36H                                       )                    TX500350
30    FORMAT (1X,36H                                        ,          TX500360
     236H                                       /                    TX500370
     31X,36H 1.PONTIUS, P. E., AND CAMERON, J. M,                     TX500380
     436H.                                      /                    TX500390
     51X,36H   REALISTIC UNCERTAINTIES AND THE M,                     TX500400
     636HASS MEASUREMENT PROCESS                /                    TX500410
     71X,36H   NAT. BUR. STAND. (U.S.), MONOGR. ,                     TX500420
     836H103                                    /                    TX500430
     91X,36H   (AUG. 15, 1967)                     ,                  TX500440
     *36H                                       )                    TX500450
40    FORMAT (1X,36H                                        ,          TX500460
     236H                                       /                    TX500470
     31X,36H 2.PONTIUS, P. E.                     ,                   TX500480
     436H                                       /                    TX500490
     51X,36H   MEASUREMENT PHILOSOPHY OF THE PIL,                     TX500500
     636HOT PROGRAM FOR MASS CALIBRATION        /                    TX500510
     71X,36H   NAT. BUR. STAND. (U.S.) TECH. NOT,                     TX500520
     836HE 288                                  /                    TX500530
     91X,36H   (MAY 6, 1966)                       ,                  TX500540
     *36H                                       )                    TX500550
50    FORMAT (1X,36H                                        ,          TX500560
     236H                                       /                    TX500570
     31X,36H 3.BOWMAN, H. A., AND SCHOONOVER, R.,                     TX500580
     436H M. WITH APPENDIX BY MILDRED JONES     /                    TX500590
     51X,36H   PROCEDURE FOR HIGH PRECISION DENS,                     TX500600
     636HITY DETERMINATIONS BY HYDROSTATIC      /                    TX500610
     71X,36H   WEIGHING                           ,                  TX500620
     836H                                       /                    TX500630
     91X,38H   J. RES. NAT. BUR. STAND. (U.S.) 71C,                   TX500640
     *36H. ENGINEERING AND INSTRUMENTATION      )                    TX500650
60    FORMAT (1X,36H   NO. 3, 179-198 (JULY-AUG. 1967)  ,            TX500660
     236H                                       /                    TX500670
     31X,36H                                      ,                   TX500680
     436H                                       /                    TX500690
     51X,36H 4.NATRELLA, M. B.                    ,                   TX500700
     636H                                       /                    TX500710
     71X,36H   EXPERIMENTAL STATISTICS              ,                 TX500720
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     836H                                        /                          TX500730
     91X,36H   NAT. BUR. STAND. (U.S.) HANDBOOK ,                           TX500740
     *36HS1                                      )                          TX500750
70    FORMAT (1X,36H   (AUGUST 1, 1963)                    ,                TX500760
     236H                                        /                          TX500770
     31X,36H                                        ,                       TX500780
     436H                                        /                          TX500790
     51X,36H S.KU, H. H.                            ,                       TX500800
     636H                                        /                          TX500810
     71X,36H   PRECISION MEASUREMENT AND CALIBRA,                           TX500820
     836HTION - SELECTED NBS PAPERS ON           /                          TX500830
     91X,36H   STATISTICAL CONCEPTS AND PROCEDUR,                           TX500840
     *36HES                                      )                          TX500850
80    FORMAT (1X,36H   NAT. BUR. STAND. (U.S.) SPEC. PUB,                    TX500860
     236HL. 300                                  /                          TX500870
     31X,36H   VOL. 1 (FEB. 1969)                   ,                       TX500880
     436H                                        /                          TX500890
     51X,36H                                        )                       TX500900
90    FORMAT (1X,36H 6.PONTIUS, P. E.                      ,                TX500910
     236H                                        /                          TX500920
     31X,36H   MASS AND MASS VALUES                 ,                       TX500930
     436H                                        /                          TX500940
     51X,36H   NAT. BUR. STAND. (U.S.) MONOGR. 1,                           TX500950
     636H33                                      /                          TX500960
     71X,36H   (JAN. 1974)                          ,                       TX500970
     836H                                        /                          TX500980
     91X,36H                                        ,                       TX500990
     *36H                                        )                          TX501000
100   FORMAT (1X,36H 7.CAMERON, J. M., CROARKIN, C. C. A,                    TX501010
     236HND RAYBOLD, R. C.                       /                          TX501020
     31X,36H   DESIGNS FOR THE CALIBRATION OF ST,                           TX501030
     436HANDARDS OF MASS                         /                          TX501040
     51X,36H   NAT. BUR. STAND. (U.S.) TECH. NOT,                           TX501050
     636HE 952                                   /                          TX501060
     71X,36H   (JUNE 1977)                          ,                       TX501070
     836H                                        /                          TX501080
     91X,36H                                        ,                       TX501090
     *36H                                        )                          TX501100
110   FORMAT (1X,36H 8.VARNER, R. N., AND RAYBOLD, R. C.,                    TX501110
     236H                                        /                          TX501120
     31X,36H   NATIONAL BUREAU OF STANDARDS MASS,                           TX501130
     436H CALIBRATION COMPUTER SOFTWARE          /                          TX501140
     51X,36H   NAT. BUR. STAND. (U.S.) TECH. NOT,                           TX501150
     636HE                                       /                          TX501160
     71X,36H   (IN PROCESS)                          ,                       TX501170
     836H                                        /                          TX501180
     91X,36H                                        ,                       TX501190
     *36H                                        )                          TX501200
      END                                                                   TX501210
--- TEXT6 SUBPROGRAM ---
      SUBROUTINE TEXT6                                                      TX600010
C*************************************************************************TX600020
C**   SUBROUTINE OF THE NATIONAL BUREAU OF STANDARDS MASS CALIBRATION **TX600030
C**   PROGRAM VERSION OF SEPT. 10, 1971   WRITTEN BY R.C. RAYBOLD     **TX600040
C**   AND MRS.R.N. VARNER                                             **TX600050
C**   MODIFIED BY R. N. VARNER SEPT 1977                              **TX600060
C*************************************************************************TX600070
      COMMON/UNITIO/IR,IW,IP,IPL,ITMP                                       TX600080
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      WRITE (IW,10)                                                    TX600090
      WRITE (IW,20)                                                    TX600100
      WRITE (IW,30)                                                    TX600110
      RETURN                                                           TX600120
C*****************************************************************TX600130
C**   FORMAT STATEMENTS                                            **TX600140
C*****************************************************************TX600150
10    FORMAT (1X,36HTO BE PUBLISHED:                  ,              TX600160
     236H                                        /                   TX600170
     31X,36H                                        ,                TX600180
     436H                                        /                   TX600190
     51X,36H 9.PONTIUS, P. E.                       ,                TX600200
     636H                                        /                   TX600210
     71X,36H   THE ACCEPTED VALUES AND ASSOCIATE,                     TX600220
     836HD UNCERTAINTY ESTIMATES OF THE NBS  /                        TX600230
     91X,36H   STANDARDS AT THE 1 KG LEVEL      ,                     TX600240
     *36H                                       )                    TX600250
20    FORMAT (1X,36H   NAT. BUR. STAND. (U.S.) TECH. NOT,              TX600260
     236HE                                       /                   TX600270
     31X,36H   (EXPECTED COMPLETION:  1975)     ,                     TX600280
     436H                                        /                   TX600290
     51X,36H                                        ,                TX600300
     636H                                        /                   TX600310
     71X,36H 10.PONTIUS, P. E.                      ,                TX600320
     836H                                        /                   TX600330
     91X,36H   DOCUMENTATION FOR THE MASS MEASUR,                     TX600340
     *36HEMENT PROCESS AT NBS                   )                    TX600350
30    FORMAT (1X,36H   NAT. BUR. STAND. (U.S.) TECH. NOT,              TX600360
     236HE                                       /                   TX600370
     31X,36H   (EXPECTED COMPLETION: 1974)      ,                     TX600380
     436H                                       )                    TX600390
      END                                                              TX600400
--- READ2 SUBPROGRAM ---
      SUBROUTINE READ2                                                 RD200010
C*****************************************************************RD200020
C**   SUBROUTINE OF THE NATIONAL BUREAU OF STANDARDS MASS CALIBRATION **RD200030
C**   PROGRAM  VERSION OF SEPT.10,1971     WRITTEN BY R.C.RAYBOLD     **RD200040
C**   AND MRS.R.N.VARNER                                             **RD200050
C**   MODIFIED BY R. N. VARNER SEPT 1979                             **RD200060
C*****************************************************************RD200070
C**   SUBROUTINE TO READ DATA FOR EACH NEW SERIES                    **RD200080
C*****************************************************************RD200090
C**   DIMENSION FOR COMMON /PRT1/ VARIABLES                          **RD200100
C*****************************************************************RD200110
      DIMENSION B1(72),B2(72),B3(72),B4(72),B5(72),B6(72),B7(72),      RD200120
     2 IDATE(3)                                                        RD200130
C*****************************************************************RD200140
C**   DIMENSION FOR COMMON /INPUT/ VARIABLES                         **RD200150
C*****************************************************************RD200160
      DIMENSION AIDCST(5,15),ANOM(15),DENSTY(15),COEFEX(15),ACCVAL(15), RD200170
     2 ARSTIN(15),ACKSTD(15),IRSTCU(15),IPRNT(15),DESMAT(15,50),       RD200180
     3 OBSERV(600),ALCOM(15,20)                                        RD200190
C*****************************************************************RD200200
C**   DIMENSION FOR COMMON /RAREA/ VARIABLES                         **RD200210
C*****************************************************************RD200220
      DIMENSION AA(72),AAITEM(5)                                       RD200230
C*****************************************************************RD200240
C**   DIMENSION FOR COMMON /PRTLE/ VARIABLE                          **RD200250
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C*************************************************************************RD200260
      DIMENSION PRTLBX(15)                                                RD200270
C*************************************************************************RD200280
C**   LABELED COMMON                                                    **RD200290
C*************************************************************************RD200300
      COMMON /PRT1/ B1,B2,B3,B4,B5,B6,B7,RANERR,SYSERR,TNOM,L1,L2,L3,L4,RD200310
     2 L5,L6,IDATE,IEREST                                                 RD200320
      COMMON /INPUT/ YEAR,PBAR,FEAR,STDEEA,SWT,VSWT,CEXSWT,AIDCST,ANOM,  RD200330
     2 DENSTY,COEFEX,ACCVAL,ARSTIN,ACKSTD,DESMAT,OBSERV,VARBAL,ALCOM,T1PRD200340
     3,T2P,P1P,P2P,H1P,H2P,CP1,CP2,CT1,CT2,CH1,CH2,OT1P,OT2P,CF1P,OP2P,  RD200350
     4 OH1P,OH2P,IOP,IBAL,NCES,NUNKN,IRSTCU,IPRNT,ITPOS,ICKUSD,ICALDS,   RD200360
     5 LINVAR,N3,N4                                                       RD200370
      COMMON /RAREA/ AA,AAITEM                                            RD200380
      COMMON /PRTLB/ PRTLBX                                               RD200390
C*************************************************************************RD200400
C**   SET UP VARIABLE FOR MAXIMUM NUMBER OF READINGS NR=50*12           **RD200410
C*************************************************************************RD200420
      NR=50*12                                                            RD200430
C*************************************************************************RD200440
C**   READ ONE CARD--FREE FIELD                                         **RD200450
C**        TYPE OF WEIGHING (N1)                                        **RD200460
C**        TYPE OF BALANCE (N2)                                         **RD200470
C**        TYPE OF UNITS OF INPUT (N3)                                  **RD200480
C**        DIRECTION OF SCALE LEFT TO RIGHT OR RIGHT TO LEFT (N4)       **RD200490
C**                                                                     **RD200500
C**   WHERE                                                             **RD200510
C**     N1 = 0      SINGLE TRANSPOSITION                                **RD200520
C**     N1 = 1      DOUBLE TRANSPOSITION                                **RD200530
C**     N1 = 2      SINGLE SUBSTITUTION                                 **RD200540
C**     N1 = 3      DOUBLE SUBSTITUTION                                 **RD200550
C**                                                                     **RD200560
C**     N2 = 0      TWO PAN BALANCE                                     **RD200570
C**     N2 = 1      ONE PAN BALANCE                                     **RD200580
C**                                                                     **RD200590
C**     N3 = 0      METRIC UNITS                                        **RD200600
C**     N3 = 1      ENGLISH UNITS                                       **RD200610
C**                                                                     **RD200620
C**     N4 = 0      SCALE LEFT TO RIGHT (EG. 0 TO 100  OR -1 TO 1)      **RD200630
C**     N4 = 1      SCALE RIGHT TO LEFT (EG. 100 TO 0  OR 1 TO -1)      **RD200640
C*************************************************************************RD200650
      CALL READIT (AA,1,AAITEM)                                           RD200660
      N1=INT(AA(1)+.1)                                                    RD200670
      N2=INT(AA(2)+.1)                                                    RD200680
      N3=INT(AA(3)+.1)                                                    RD200690
      N4=INT(AA(4)+.1)                                                    RD200700
C*************************************************************************RD200710
C**   READ DATE OF OBSERVATION,OPERATOR,BALANCE AND CHECK STANDARD      **RD200720
C**   USED                                                              **RD200730
C**   WHERE   NUMBERS ARE FREE FIELD ON THIS CARD  6 NUMBERS            **RD200740
C**        MONTH AND DAY (2 DIGITS) YEAR (4 DIGITS)                     **RD200750
C**     OPERATOR CODE (INTEGER)                                         **RD200760
C**     BALANCE CODE (INTEGER)                                          **RD200770
C**     CHECK STANDARD CODE (INTEGER)                                   **RD200780
C*************************************************************************RD200790
      CALL READIT (AA,1,AAITEM)                                           RD200800
      IDATE(1)=INT(AA(1)+.1)                                              RD200810
      IDATE(2)=INT(AA(2)+.1)                                              RD200820
      IDATE(3)=INT(AA(3)+.1)                                              RD200830
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      IOP=INT(AA(4)+.1)                                                 RD200840
      IBAL=INT(AA(5)+.1)                                                RD200850
      ICKUSD=INT(AA(6)+.1)                                              RD200860
C*****************************************************************RD200870
C**    READ TEMPERATURE,PRESSURE,HUMIDITY AND THEIR CORRECTIONS      **RD200880
C**   ONE RECORD FREE FIELD WITH ENTRIES IN THE FOLLOWING ORDER      **RD200890
C**    1-TEMPERATURE AT BEGINNING OF THE SERIES IN DEGREES C         **RD200900
C**    2-TEMPERATURE AT END OF THE SERIES IN DEGREES C               **RD200910
C**    3-PRESSURE AT BEGINNING IN MM HG                             **RD200920
C**    4-PRESSURE AT END IN MM HG                                   **RD200930
C**    5-HUMIDITY AT BEGINNING IN PERCENT                           **RD200940
C**    6-HUMIDITY AT END IN PERCENT                                 **RD200950
C**    7-PRESSURE CORRECTION BEGINNING IN MM HG                     **RD200960
C**    8-PRESSURE CORRECTION END IN MM HG                           **RD200970
C**    9-TEMPERATURE CORRECTION BEGINNING IN DEGREES C              **RD200980
C**   10-TEMPERATURE CORRECTION END IN DEGREES C                    **RD200990
C**   11-HUMIDITY CORRECTION BEGINNING IN PERCENT                   **RD201000
C**   12-HUMIDITY CORRECTION END IN PERCENT                         **RD201010
C*****************************************************************RD201020
      CALL READIT (AA,1,AAITEM)                                         RD201030
      T1P=AA(1)                                                         RD201040
      T2P=AA(2)                                                         RD201050
      P1P=AA(3)                                                         RD201060
      P2P=AA(4)                                                         RD201070
      H1P=AA(5)                                                         RD201080
      H2P=AA(6)                                                         RD201090
      CP1=AA(7)                                                         RD201100
      CP2=AA(8)                                                         RD201110
      CT1=AA(9)                                                         RD201120
      CT2=AA(10)                                                        RD201130
      CH1=AA(11)                                                        RD201140
      CH2=AA(12)                                                        RD201150
C*****************************************************************RD201160
C**    SAVE VALUES FOR OUTPUT                                        **RD201170
C**    COMPUTE AVERAGE CORRECTED TEMPERATURE, PRESSURE AND HUMIDITY  **RD201180
C*****************************************************************RD201190
      OT1P=T1P                                                          RD201200
      OT2P=T2P                                                          RD201210
      OP1P=P1P                                                          RD201220
      OP2P=P2P                                                          RD201230
      OH1P=H1P                                                          RD201240
      OH2P=H2P                                                          RD201250
      T1P=T1P+CT1                                                       RD201260
      T2P=T2P+CT2                                                       RD201270
      P1P=P1P+CP1                                                       RD201280
      P2P=P2P+CP2                                                       RD201290
      H1P=H1P+CH1                                                       RD201300
      H2P=H2P+CH2                                                       RD201310
      TEAR=(T1P+T2P)/2.                                                 RD201320
      PBAR=(P1P+P2P)/2.                                                 RD201330
      HBAR=(H1P+H2P)/2.                                                 RD201340
C*****************************************************************RD201350
C**    ONE CARD IN THE FOLLOWING ORDER FREE FIELD                    **RD201360
C**     1. NUMBER OF OBSERVATION  ( MAX. = 50 )                      **RD201370
C**     2. NUMBER OF UNKNOWNS  ( MAX. = 15 )                         **RD201380
C**     3. CALIBRATION DESIGN CODE  ( INTEGER 0000 TO 9999 )         **RD201390
C**     4. NUMBER OF LINEAR COMBINATION ( MAX. = 20 )                **RD201400
C*****************************************************************RD201410
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      CALL READIT (AA,1,AAITEM)                                          RD201420
      NOBS=INT(AA(1)+.1)                                                 RD201430
      NUNKN=INT(AA(2)+.1)                                                RD201440
      ICALDS=INT(AA(3)+.1)                                               RD201450
      LINVAR=INT(AA(4)+.1)                                               RD201460
C*****************************************************************RD201470
C**   ONE RECORD-FREE FIELD-WITH ENTRIES IN THE FOLLOWING ORDER      **RD201480
C**    1. WITHIN STANDARD DEVIATION OF THE BALANCE IN MG             **RD201490
C**    2. MASS VALUE IN MG OF THE SENSITIVITY WEIGHT                 **RD201500
C**    3. VOLUME OF THE SENSITIVITY WEIGHT IN CM3                    **RD201510
C**    4. COEFFICIENT OF EXPANSION OF SENSITIVITY WEIGHT             **RD201520
C**    5. BETWEEN STANDARD DEVIATION OF THE BALANCE IN MG            **RD201530
C*****************************************************************RD201540
      CALL READIT (AA,1,AAITEM)                                          RD201550
      STDEBA=AA(1)                                                       RD201560
      SWT=AA(2)                                                          RD201570
      VSWT=AA(3)                                                         RD201580
      CEXSWT=AA(4)                                                       RD201590
      VAREAL=AA(5)                                                       RD201600
C*****************************************************************RD201610
C**   A GROUP OF N RECORDS (N=NUMBER OF UNKNOWNS), EACH RECORD HAS   **RD201620
C**   INFORMATION IN THE FOLLOWING ORDER, ABOUT EACH WEIGHT          **RD201630
C**     1. IN COLUMNS 1-15 IDENTIFICATION OF WEIGHTS (ALPHA-NUMERIC) **RD201640
C**                                                                  **RD201650
C**   THE REST OF THE INFORMATION ON EACH RECORD IS FREE FIELD       **RD201660
C**                                                                  **RD201670
C**     2. WEIGHTS NOMINAL VALUE IN GRAMS ( POUNDS IF N3 = 1 )       **RD201680
C**     3. DENSITY OF THE WEIGHT IN CM3                              **RD201690
C**     4. COEFFICIENT OF EXPANSION OF THE WEIGHT                    **RD201700
C**     5. ACCEPTED CORRECTION OF THE WEIGHT IN MG                   **RD201710
C*****************************************************************RD201720
      DO 20 I=1,NUNKN                                                    RD201730
      CALL READIT (AA,16,AAITEM)                                         RD201740
      AIDCST(1,I)=AAITEM(1)                                              RD201750
      AIDCST(2,I)=AAITEM(2)                                              RD201760
      AIDCST(3,I)=AAITEM(3)                                              RD201770
      AIDCST(4,I)=AAITEM(4)                                              RD201780
      AIDCST(5,I)=AAITEM(5)                                              RD201790
      ANOM(I)=AA(1)                                                      RD201800
      IF (N3.EQ.0) GO TO 10                                              RD201810
      PRTLBX(I)=ANOM(I)                                                  RD201820
C*****************************************************************RD201830
C**   CONVERT POUNDS TO GRAMS                                        **RD201840
C*****************************************************************RD201850
      ANOM(I)=ANOM(I)*453.59237                                          RD201860
10    CONTINUE                                                           RD201870
      DENSTY(I)=AA(2)                                                    RD201880
      COEFEX(I)=AA(3)                                                    RD201890
      ACCVAL(I)=AA(4)                                                    RD201900
20    CONTINUE                                                           RD201910
C*****************************************************************RD201920
C**   READ, FREE FIELD, ONE RECORD A VECTOR CONSISTING OF 1'S OF 0'S **RD201930
C**   USE A 1 IF WEIGHT IS INCLUDED IN RESTRAINT                     **RD201940
C**   USE A 0 IF WEIGHT IS NOT INCLUDED IN THE RESTRAINT             **RD201950
C**   FOLLOW ORDER OF INPUT                                          **RD201960
C*****************************************************************RD201970
      CALL READIT (AA,1,AAITEM)                                          RD201980
      DO 30 I=1,NUNKN                                                    RD201990
```

```
30    ARSTIN(I)=AA(I)                                                    RD202000
C*****************************************************************RD202010
C**   READ, FREE FIELD, ONE RECORD CONSISTING OF 1'S AND 0'S          **RD202020
C**   USE 1 IF WEIGHT IS INCLUDED IN CHECK STANDARD                   **RD202030
C**   USE 0 IF WEIGHT IS NOT INCLUDED IN CHECK STANDARD               **RD202040
C**   FOLLOW ORDER OF INPUT                                           **RD202050
C*****************************************************************RD202060
      CALL READIT (AA,1,AAITEM)                                        RD202070
      DO 40 I=1,NUNKN                                                  RD202080
40    ACKSTD(I)=AA(I)                                                  RD202090
C*****************************************************************RD202100
C**   READ, FREE FIELD, ONE RECORD CONSISTING OF 1'S AND 0'S          **RD202110
C**   USE 1 IF WEIGHT IS USED IN RESTRAINT FOR NEXT SERIES            **RD202120
C**   USE 0 IF WEIGHT IS NOT USED IN RESTRAINT FOR NEXT SERIES        **RD202130
C**   FOLLOW ORDER ON INPUT                                           **RD202140
C*****************************************************************RD202150
      CALL READIT (AA,1,AAITEM)                                        RD202160
      DO 50 I=1,NUNKN                                                  RD202170
50    IRSTOU(I)=INT(AA(I)+.1)                                          RD202180
C*****************************************************************RD202190
C**   READ IN FREE FIELD A CARD WITH A VECTOR OF 1 IF WEIGHT IS ONE   **RD202200
C**   WHICH IS TO BE PRINTED IN THE REPORT AND 0 IF IT IS NOT , THE   **RD202210
C**   READ, FREE FIELD, ONE RECORD CONSISTING OF 1'S AND 0'S          **RD202220
C**   USE 1 IF WEIGHT IS TO BE PRINTED IN REPORT                      **RD202230
C**   USE 0 IF WEIGHT IS OMITTED IN REPORT                            **RD202240
C**   USE ORDER OF INPUT                                              **RD202250
C*****************************************************************RD202260
      CALL READIT (AA,1,AAITEM)                                        RD202270
      DO 60 I=1,NUNKN                                                  RD202280
60    IPRNT(I)=INT(AA(I)+.1)                                           RD202290
C*****************************************************************RD202300
C**   READ DESIGN MATRIX                                              **RD202310
C**   READ IN N (NUMBER OF OBSERVATIONS) RECORDS WITH K (NUMBER       **RD202320
C**   OF UNKNOWNS)                                                    **RD202330
C**   ENTRIES PER RECORD IN THE ORDER OF THE                          **RD202340
C**   IDENTIFICATION CARDS WHERE THE WEIGHING EQUATION ARE SET UP BY   **RD202350
C**   A SERIES OF 0,-1 AND 1 .                                        RD202360
C*****************************************************************RD202370
      DO 80 I=1,NOBS                                                   RD202380
      CALL READIT (AA,1,AAITEM)                                        RD202390
      DO 70 J=1,NUNKN                                                  RD202400
      DESMAT(J,I)=AA(J)                                                RD202410
70    CONTINUE                                                         RD202420
80    CONTINUE                                                         RD202430
C*****************************************************************RD202440
C**   READ IN LINVAR (NUMBER OF LINEAR COMBINATIONS) RECORDS          **RD202450
C**   TO COMPUTE VARIANCE OF LINEAR COMBINATIONS OF WEIGHTS           **RD202460
C**   EACH RECORD CONTAINS K (NUMBER OF UNKNOWNS) ENTRIES             **RD202470
C**   ENTRIES OF 0'S, -1'S, AND 1'S ARE USED                          **RD202480
C**   FOLLOW ORDER OF INPUT                                           **RD202490
C*****************************************************************RD202500
      IF (LINVAR.EQ.0) GO TO 110                                       RD202510
      DO 100 I=1,LINVAR                                                RD202520
      CALL READIT (AA,1,AAITEM)                                        RD202530
      DO 90 J=1,NUNKN                                                  RD202540
      ALCOM(J,I)=AA(J)                                                 RD202550
90    CONTINUE                                                         RD202560
100   CONTINUE                                                         RD202570
```

```
C*****************************************************************RD202580
C**   READ OBSERVATIONS FREE FIELD IN THE ORDER THAT THE DESIGN      **RD202590
C**   MATRIX IS READ                                                 **RD202600
C**   READ ENTRIES AS DENOTED BY N1 AND N2 BELOW                     **RD202610
C**                                                                  **RD202620
C**    N1 N2                                                         **RD202630
C**    2   1   X Y Z                                                 **RD202640
C**    2   0   X1 X2 X3 Y1 Y2 Y3 Z1 Z2 Z3                            **RD202650
C**    0   0   X1 X2 X3 Y1 Y2 Y3 Z1 Z2 Z3                            **RD202660
C**    3   1   X Y Z W                                               **RD202670
C**    3   0   2-CARDS   X1 X2 X3 Y1 Y2 Y3                          **RD202680
C**                      Z1 Z2 Z3 W1 W2 W3                          **RD202690
C**    1   0   2-CARDS   X1 X2 X3 Y1 Y2 Y3                          **RD202700
C**                      Z1 Z2 Z3 W1 W2 W3                          **RD202710
C**                                                                  **RD202720
C**   NOTES                                                          **RD202730
C**      1. ANY OTHER COMBINATION OF N1 AND N2 ASSUMES THERE ARE TWO  **RD202740
C**   RECORDS, SIX ITEMS PER RECORD                                  **RD202750
C**      2. THE MAXIMUM NUMBER OF OBSERVATIONS IS 50 SO YOU MAY HAVE UP RD202760
C**         TO 600 READINGS GIVEN HERE                               **RD202770
C**      3. NO MORE OBSERVATIONS ARE STORED WHEN                     **RD202780
C**         -20000 IS ENCOUNTERED                                    **RD202790
C*****************************************************************RD202800
110   DO 120 K=1,NR                                                  RD202810
      OBSERV(K)=0.0                                                  RD202820
120   CONTINUE                                                       RD202830
      K=1                                                            RD202840
C*****************************************************************RD202850
C**   SET UP FLAGS FOR TYPE OF WEIGHING                              **RD202860
C*****************************************************************RD202870
      IF (N1.EQ.2.AND.N2.EQ.1) GO TO 130                             RD202880
      IF (N1.EQ.2.AND.N2.EQ.0) GO TO 140                             RD202890
      IF (N1.EQ.0.AND.N2.EQ.0) GO TO 150                             RD202900
      IF (N1.EQ.3.AND.N2.EQ.1) GO TO 160                             RD202910
      IF (N1.EQ.3.AND.N2.EQ.0) GO TO 170                             RD202920
      IF (N1.EQ.1.AND.N2.EQ.0) GO TO 180                             RD202930
      GO TO 180                                                      RD202940
130   IA=3                                                           RD202950
      ITPCS=1                                                        RD202960
      GO TO 190                                                      RD202970
140   IA=9                                                           RD202980
      ITPCS=2                                                        RD202990
      GO TO 190                                                      RD203000
150   IA=9                                                           RD203010
      ITPCS=3                                                        RD203020
      GO TO 190                                                      RD203030
160   IA=4                                                           RD203040
      ITPCS=4                                                        RD203050
      GO TO 190                                                      RD203060
170   IA=6                                                           RD203070
      ITPCS=5                                                        RD203080
      GO TO 190                                                      RD203090
180   IA=6                                                           RD203100
      ITPCS=6                                                        RD203110
      GO TO 190                                                      RD203120
C*****************************************************************RD203130
C**   READ OBSERVATIONS--FREE FIELD INPUT                            **RD203140
C**   THE NUMBER -20000  DENOTES LAST CARD FOR A SERIES              **RD203150
```

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C*****************************************************************RD203160
190   CALL READIT (AA,1,AAITEM)                                     RD203170
      IF (AA(1).LE.-19999.) GO TO 210                               RD203180
      DO 200 I=1,IA                                                 RD203190
      OBSERV(K)=AA(I)                                               RD203200
      K=K+1                                                         RD203210
200   CONTINUE                                                      RD203220
      GO TO 190                                                     RD203230
210   RETURN                                                        RD203240
      END                                                           RD203250
--- SPINV SUBPROGRAM ---
      SUBROUTINE SPINV (A,M,KK,ISIG)                                INV00010
C*****************************************************************INV00020
C**   SUBROUTINE OF THE NATIONAL BUREAU OF STANDARDS MASS CALIBRATION **INV00030
C**   PROGRAM  VERSION OF SEPT.10,1971     WRITTEN BY R.C.RAYBOLD   **INV00040
C**   AND MRS.R.N.VARNER                                            **INV00050
C**   MODIFIED BY R. N. VARNER SEPT 1979                            **INV00060
C*****************************************************************INV00070
C**   MATRIX INVERSION WITH MINIMUM ROUNDOFF ERROR ACCUMULATION.    **INV00080
C**   WRITTEN BY MRS.S.T.PEAVY ,STATISTICAL ENGINEERING LABORATORY ,  **INV00090
C**   NATIONAL BUREAU OF STANDARDS ,WASHINGTON , D.C. 20234         **INV00100
C**   A IS THE MATRIX TO BE INVERTED                                **INV00110
C**   M IS THE NUMBER OF ROWS IN MATRIX                             **INV00120
C**   KK IS THE NUMBER OF COLUMNS IN MATRIX                         **INV00130
C**   ISIG=0 INVERSE SUCCESSFUL                                     **INV00140
C**   ISIG=4 SINGULAR MATRIX                                        **INV00150
C**   ISIG=-1 CHECK ON I(IDENTITY)-A*A(INVERSE) FAILED              **INV00160
C*****************************************************************INV00170
      DIMENSION A(1)                                                INV00180
      COMMON /INVCST/ ZERMAC                                        INV00190
C*****************************************************************INV00200
C**   SAVE ORIGINAL MATRIX                                          **INV00210
C*****************************************************************INV00220
      CALL SAVMTX (M)                                               INV00230
      ISIG=0                                                        INV00240
      N=M                                                           INV00250
      NN=KK                                                         INV00260
      N2=N+N                                                        INV00270
      DO 30 J=1,N                                                   INV00280
      NJCOL=(N+J-1)*NN                                              INV00290
      DO 30 I=1,N                                                   INV00300
      KINJ=NJCOL+I                                                  INV00310
      IF (I-J) 10,20,10                                             INV00320
10    A(KINJ)=0.                                                    INV00330
      GO TO 30                                                      INV00340
20    A(KINJ)=1.                                                    INV00350
30    CONTINUE                                                      INV00360
C*****************************************************************INV00370
C**   DETERMINE MAXIMUM ABSOLUTE OF VARIABLE BEING ELIMINATED.      **INV00380
C*****************************************************************INV00390
      L=0                                                           INV00400
40    L=L+1                                                         INV00410
      LCOL=NN*L-NN                                                  INV00420
      KLL=LCOL+L                                                    INV00430
      IF (L-N) 50,100,200                                           INV00440
C*****************************************************************INV00450
C**   FIND THE LARGEST ELEMENT IN THE LTH COLUMN.                   **INV00460
C*****************************************************************INV00470
```

```
50    J1=L                                                              INV00480
      C=AES(A(KLL))                                                     INV00490
      L1=L+1                                                            INV00500
      DO 70 I=L1,N                                                      INV00510
      KIL=LCCL+I                                                        INV00520
      X=AES(A(KIL))                                                     INV00530
      IF (C-X) 60,70,70                                                 INV00540
C*************************************************************************INV00550
C**   RECORD THE NUMBER OF THE ROW HAVING THE GREATER ELEMENT.         **INV00560
C*************************************************************************INV00570
60    J1=I                                                              INV00580
C*************************************************************************INV00590
C**   C BECOMES THE GREATER.                                           **INV00600
C*************************************************************************INV00610
      C=X                                                               INV00620
70    CONTINUE                                                          INV00630
C*************************************************************************INV00640
C**   INTERCHANGE ROW J1 WITH ROW L. J1 IS THE ROW WITH THE LARGEST    **INV00650
C**   ELEMENT TEST TO SEE IF INTERCHANGING IS NECESSARY.               **INV00660
C*************************************************************************INV00670
      IF (J1-L) 80,100,80                                               INV00680
80    DO 90 J=L,N2                                                      INV00690
      JCOL=NN*J-NN                                                      INV00700
      KJIJ=JCOL+J1                                                      INV00710
      HOLD=A(KJIJ)                                                      INV00720
      KLJ=JCOL+L                                                        INV00730
      A(KJIJ)=A(KLJ)                                                    INV00740
      A(KLJ)=HOLD                                                       INV00750
90    CONTINUE                                                          INV00760
C*************************************************************************INV00770
C**   IF  THE LARGEST ABSOLUTE ELEMENT IN A COLUMN IS ZERO WE HAVE     **INV00780
C**   A SINGULAR MATRIX                                                **INV00790
C*************************************************************************INV00800
100   IF (ABS(A(KLL))-ZERMAC) 110,110,120                               INV00810
110   ISIG=4                                                            INV00820
      GO TO 200                                                         INV00830
C*************************************************************************INV00840
C**   ZERO ALL THE ELEMENTS IN THE LTH COLUMN BUT THE PIVOTAL ELEMENT  **INV00850
C*************************************************************************INV00860
120   L1=1                                                              INV00870
      L2=L-1                                                            INV00880
      IF (L2) 130,130,150                                               INV00890
130   IF (L-N) 140,170,140                                              INV00900
140   L1=L+1                                                            INV00910
      L2=N                                                              INV00920
150   DO 160 I=L1,L2                                                    INV00930
      KIL=LCCL+I                                                        INV00940
      Z=-A(KIL)/A(KLL)                                                  INV00950
      DO 160 J=L,N2                                                     INV00960
      JCOL=NN*J-NN                                                      INV00970
      KIJ=JCCL+I                                                        INV00980
      KLJ=JCCL+L                                                        INV00990
160   A(KIJ)=A(KIJ)+Z*A(KLJ)                                            INV01000
      IF (N-L2) 40,40,130                                               INV01010
C*************************************************************************INV01020
C**   DIVIDE BY DIAGONAL ELEMENTS.                                     **INV01030
C*************************************************************************INV01040
170   DO 180 I=1,N                                                      INV01050
```

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      KKK=NN*I-NN+I                                                     INV01060
      ZZ=A(KKK)                                                         INV01070
      DO 180 J=1,N2                                                     INV01080
      KKI=NN*J-NN+I                                                     INV01090
180   A(KKI)=A(KKI)/ZZ                                                  INV01100
C*****************************************************************    INV01110
C**   RETURN AFTER PUTTING A INVERSE INTO B                          **INV01120
C*****************************************************************    INV01130
      DO 190 J=1,N                                                      INV01140
      JCOL=NN*J-NN                                                      INV01150
      NJCCL=NN*N+JCOL                                                   INV01160
      DO 190 I=1,N                                                      INV01170
      KIJ=JCCL+I                                                        INV01180
      KINJ=NJCCL+I                                                      INV01190
190   A(KIJ)=A(KINJ)                                                    INV01200
C*****************************************************************    INV01210
C**   CHECK SUCCESS CR FAILURE CF MATRIX INVERSION                   **INV01220
C*****************************************************************    INV01230
      CALL INVCHK (A,N,KK,ISIG)                                         INV01240
200   RETURN                                                            INV01250
      END                                                               INV01260
--- SAVMTX SUBPROGRAM ---
      SUBROUTINE SAVMTX (M)                                             SVM00010
C*****************************************************************    SVM00020
C**   SUBROUTINE OF THE NATICNAL BUREAU OF STANDARDS MASS CALIBRATICN **SVM00030
C**   PROGRAM  VERSICN CF SEPT.10,1971     WRITTEN BY R.C.RAYECLD     **SVM00040
C**   AND MRS.R.N.VARNER                                             **SVM00050
C**   MODIFIED BY R. N. VARNER SEPT 1979                             **SVM00060
C*****************************************************************    SVM00070
C**   SUBROUTINE TO SAVE ORIGINAL MATRIX BEFORE INVERSION            **SVM00080
C**   MATRIX IS IN Y AND IS STCRED IN B                              **SVM00090
C*****************************************************************    SVM00100
C**   DIMENSICN FCR COMMCN /CHECK/ VARIABLES                         **SVM00110
C*****************************************************************    SVM00120
      DIMENSICN B(289),Y(578)                                           SVM00130
C*****************************************************************    SVM00140
C**   LABELEC COMMON                                                 **SVM00150
C*****************************************************************    SVM00160
      COMMCN /CHECK/ CHCKMA,B,Y                                         SVM00170
      MA=M*M                                                            SVM00180
      DO 10 I=1,MA                                                      SVM00190
10    B(I)=Y(I)                                                         SVM00200
      RETURN                                                            SVM00210
      END                                                               SVM00220
--- INVCHK SUBPROGRAM ---
      SUBROUTINE INVCHK (A,M,KK,ISIG)                                   IVC00010
C*****************************************************************    IVC00020
C**   SUBROUTINE OF THE NATICNAL BUREAU OF STANDARDS MASS CALIBRATION **IVC00030
C**   PROGRAM  VERSICN CF SEPT.10,1971     WRITTEN BY R.C.RAYECLD     **IVC00040
C**   AND MRS.R.N.VARNER                                             **IVC00050
C**   MODIFIED BY R. N. VARNER SEPT 1979                             **IVC00060
C*****************************************************************    IVC00070
C**   SUBRCUTINE TO CHECK  I-AA(INV)                                 **IVC00080
C**   A IS INVERTED MATRIX                                           **IVC00090
C**   B IS ORIGINAL MATRIX                                           **IVC00100
C**   M IS NUMBER OF ROWS IN MATRIX                                  **IVC00110
C**   KK IS NUMBER OF COLUMNS IN MATRIX                              **IVC00120
C**   ISIG=-1 IF I-A*A(INV) FAILS                                    **IVC00130
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C*************************************************************************IVC00140
      DIMENSION A(1)                                                      IVC00150
C*************************************************************************IVC00160
C**   DIMENSION FOR COMMON /CHECK/                                      **IVC00170
C*************************************************************************IVC00180
      DIMENSION B(289),Y(578)                                             IVC00190
C*************************************************************************IVC00200
C**   LABELED COMMON                                                    **IVC00210
C**                                                                     **IVC00220
      COMMON /CHECK/ CHCKMA,B,Y                                           IVC00230
      N=M                                                                 IVC00240
      NN=KK                                                               IVC00250
C*************************************************************************IVC00260
C**   RESTORE ORIGINAL MATRIX                                           **IVC00270
C*************************************************************************IVC00280
      NP=N*N                                                              IVC00290
      DO 10 J=1,NP                                                        IVC00300
      NP2=NP+J                                                            IVC00310
10    A(NP2)=B(J)                                                         IVC00320
C*************************************************************************IVC00330
C**   B=I-AA(INV)                                                       **IVC00340
C*************************************************************************IVC00350
      IBP=1                                                               IVC00360
      K=1                                                                 IVC00370
      DO 60 J=1,NN                                                        IVC00380
      IAP=N*N+1                                                           IVC00390
      DO 50 KA=1,N                                                        IVC00400
      IA=IAP                                                              IVC00410
      IB=IBP                                                              IVC00420
      B(K)=0.0                                                            IVC00430
      DO 20 I=1,NN                                                        IVC00440
      B(K)=B(K)+A(IA)*A(IB)                                               IVC00450
      IB=IB+1                                                             IVC00460
20    IA=IA+N                                                             IVC00470
      IF (J.EQ.KA) GO TO 30                                               IVC00480
      B(K)=-B(K)                                                          IVC00490
      GO TO 40                                                            IVC00500
30    B(K)=1.0-B(K)                                                       IVC00510
40    IAP=IAP+1                                                           IVC00520
50    K=K+1                                                               IVC00530
60    IBP=IBP+N                                                           IVC00540
C*************************************************************************IVC00550
C**   PICK UP THE LARGEST ABSOLUTE VALUE FROM  I-AA(INV)                **IVC00560
C*************************************************************************IVC00570
      BIG=ABS(B(1))                                                       IVC00580
      J=N*N                                                               IVC00590
      DO 70 I=2,J                                                         IVC00600
70    BIG=AMAX1(BIG,ABS(B(I)))                                            IVC00610
C*************************************************************************IVC00620
C**   IF CONDITION IS NOT MET SET SIGNAL (ISIG)=-1                      **IVC00630
C**   CHCKMA=.01*S.D. OF BALANCE(INPUT VALUE)                           **IVC00640
C*************************************************************************IVC00650
      IF (BIG.LE.CHCKMA) RETURN                                           IVC00660
      ISIG=-1                                                             IVC00670
      RETURN                                                              IVC00680
      END                                                                 IVC00690
--- PRINT2 SUBPROGRAM ---
      SUBROUTINE PRINT2                                                   PR200010
```

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C*****************************************************************PR200020
C**   SUBROUTINE OF THE NATIONAL BUREAU OF STANDARDS MASS CALIBRATION **PR200030
C**   PROGRAM  VERSION OF SEPT. 10,1971    WRITTEN BY R.C.RAYFIELD     **PR200040
C**   AND MRS.R.N.VARNER                                               **PR200050
C**   MODIFIED BY R. N. VARNER SEPT 1979                               **PR200060
C*****************************************************************PR200070
C**   SUBROUTINE TO PRINT PAGES FOR ONE SERIES                         **PR200080
C*****************************************************************PR200090
C**   DIMENSION FOR COMMON /PRT1/ VARIABLES                            **PR200100
C*****************************************************************PR200110
      DIMENSION B1(72),B2(72),B3(72),B4(72),B5(72),B6(72),B7(72),       PR200120
     2 IDATE(3)                                                         PR200130
C*****************************************************************PR200140
C**   DIMENSION FOR COMMON /INPUT/ VARIABLES                           **PR200150
C*****************************************************************PR200160
      DIMENSION AIDCST(5,15),ANOM(15),DENSTY(15),COEFEX(15),ACCVAL(15), PR200170
     2 ARSTIN(15),ACKSTD(15),IRSTCU(15),IPRNT(15),DESMAT(15,50),        PR200180
     3 CBSERV(600),ALCOM(15,20)                                         PR200190
C*****************************************************************PR200200
C**   DIMENSION FOR COMMON /COMPUT/ VARIABLES                          **PR200210
C*****************************************************************PR200220
      DIMENSION SWTPRT(50),A(50),DELTA(50),OBSCOR(15),COMVOL(15),       PR200230
     2 SERROR(15),TRISIG(15),TCTUN(15),DRIFT(50),ZERO(50),COMVOF(15),   PR200240
     3 CORR5A(20),SIG35A(20),UNC5A(20),IOTSTR(50),SER5A(20),DS1(50)     PR200250
C*****************************************************************PR200260
C**   DIMENSION FOR SUBROUTINE PRINT2                                  **PR200270
C*****************************************************************PR200280
      DIMENSION ITEMP(15),KTEMP(15),JTEMP(20)                           PR200290
C*****************************************************************PR200300
C*****************************************************************PR200310
C**   DIMENSION FOR COMMON /CHECK/ VARIABLES                           **PR200320
C*****************************************************************PR200330
      DIMENSION B(289),Y(578)                                           PR200340
C*****************************************************************PR200350
C**   DIMENSION FOR COMMON /PRTLB/ VARIABLES                           **PR200360
C*****************************************************************PR200370
      DIMENSION PRTLBX(15)                                              PR200380
C*****************************************************************PR200390
C**   LABELED COMMON                                                   **PR200400
C*****************************************************************PR200410
      COMMON /PRT1/ B1,B2,B3,B4,B5,B6,B7,RANERR,SYSERR,TNOM,L1,L2,L3,L4,PR200420
     2 L5,L6,IDATE,IEREST                                               PR200430
      COMMON /PRT2/ IPAGE,NOSER,IPGCT                                   PR200440
      COMMON /INPUT/ TEAR,PBAR,HBAR,STDEBA,SWT,VSWT,CEXSWT,AIDCST,ANOM, PR200450
     2 DENSTY,COEFEX,ACCVAL,ARSTIN,ACKSTD,DESMAT,CBSERV,VARBAL,ALCOM,T1PPR200460
     3,T2P,P1P,P2P,H1P,H2P,CP1,CP2,CT1,CT2,CH1,CH2,OT1P,OT2P,CP1P,OP2P, PR200470
     4 OH1P,OH2P,IOP,IBAL,NOBS,NUNKN,IRSTCU,IPRNT,ITPOS,ICKUSD,ICALDS,  PR200480
     5 LINVAR,N3,N4                                                     PR200490
      COMMON /COMPUT/ CESCOR,CORR,VOLRES,RHOA,SWTPRT,A,DELTA,COMVOL,    PR200500
     2 SERROR,TRISIG,TCTUN,ACCRR,CORRES,TMSUM,VOLSUM,SERSUM,T3SIG,ALOADPPR200510
     3,OBSTD,FRATIO,CBCOCK,OBSCK,TVAL,DRIFT,ZERO,V2TAU,STAR,COMVOP,     PR200520
     4 CORR5A,SIG35A,UNC5A,RHOAA,RHOAB,SER5A,DS1,NDGFR,ISWTCH,IFLAG,    PR200530
     5 IRCUT,IOTSTR,JSTAR                                               PR200540
      COMMON /PRTLB/ PRTLBX                                             PR200550
      COMMON /CHECK/ CHCKMA,B,Y                                         PR200560
      COMMON /UNITIO/ IR,IW,IP,IPL,ITMP                                 PR200570
      COMMON /DPFDVL/ KFC(18)                                           PR200580
      COMMON /PCHOUT/ NTCP                                              PR200590
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C*************************************************************************PR200600
C**    TYPE STATEMENT                                                   **PR200610
C*************************************************************************PR200620
      DOUBLE PRECISION CESCOR                                            PR200630
C*************************************************************************PR200640
      NOSER=NCSER+1                                                      PR200650
      ITST=1                                                             PR200660
      IF (NCSER.NE.1) GO TO 10                                           PR200670
      NTOP=0                                                             PR200680
      REWIND ITMP                                                        PR200690
C*************************************************************************PR200700
C**    WRITE FIRST PAGE OF SERIES                                       **PR200710
C*************************************************************************PR200720
10    CALL HEADPG                                                        PR200730
      CALL CHKLN (2)                                                     PR200740
      WRITE (IW,1140) STDEBA,VAREAL                                      PR200750
      CALL CHKLN (3)                                                     PR200760
      WRITE (IW,1150) ICALDS                                             PR200770
      DO 15 I=1,NUNKN                                                    PR200780
15    ITEMP(I)=ARSTIN(I)                                                 PR200785
      CALL CHKLN (1)                                                     PR200790
      WRITE (IW,1160) (ITEMP(I),I=1,NUNKN)                               PR200800
      CALL CHKLN (6)                                                     PR200810
      WRITE (IW,1170) CORR,TEAR,VOLRES,SYSERR,RANERR                     PR200820
      DO 20 I=1,NUNKN                                                    PR200830
20    ITEMP(I)=ACKSTD(I)                                                 PR200840
      CALL CHKLN (1)                                                     PR200850
      WRITE (IW,1190) ICKUSD                                             PR200860
      CALL CHKLN (1)                                                     PR200870
      WRITE (IW,1180) (ITEMP(I),I=1,NUNKN)                               PR200880
      CALL CHKLN (1)                                                     PR200890
      WRITE (IW,1200) V2TAU                                              PR200900
      DO 30 I=1,NUNKN                                                    PR200910
30    ITEMP(I)=IPRNT(I)                                                  PR200920
      CALL CHKLN (1)                                                     PR200930
      WRITE (IW,1040) (ITEMP(I),I=1,NUNKN)                               PR200940
      CALL CHKLN (15)                                                    PR200950
      WRITE (IW,1210) T1P,T2P,TEAR,P1P,P2P,PBAR,H1P,H2P,HEAR,RHCAB,RHOAAPR200960
     2,RHCA,CT1,CT2,CP1,CP2,CH1,CH2,CT1P,CT2P,CP1P,CP2P,CH1P,CH2P        PR200970
      CALL CHKLN (3)                                                     PR200980
      IF (N3.EQ.0) GO TO 70                                              PR200990
C*************************************************************************PR201000
C**    OUTPUT IN ENGLISH (POUNDS)                                       **PR201010
C*************************************************************************PR201020
      WRITE (IW,1220)                                                    PR201030
      DO 60 I=1,NUNKN                                                    PR201040
      CALL CHKLN (1)                                                     PR201050
      IF (ACCVAL(I)) 40,50,40                                            PR201060
40    WRITE (IW,1230) (AIRCST(IU,I),IU=1,5),PRTLBX(I),DENSTY(I),COEFEX(IPR201070
     2),ACCVAL(I)                                                        PR201080
      GO TO 60                                                           PR201090
50    WRITE (IW,1230) (AIRCST(IU,I),IU=1,5),PRTLBX(I),DENSTY(I),COEFEX(IPR201100
     2)                                                                  PR201110
60    CONTINUE                                                           PR201120
      GO TO 110                                                          PR201130
C*************************************************************************PR201140
C**    OUTPUT IN METRIC (GRAMS)                                         **PR201150
C*************************************************************************PR201160
```

```
70    WRITE (IW,1250)                                                    PR201170
      DO 100 I=1,NUNKN                                                   PR201180
      CALL CHKLN (1)                                                     PR201190
      IF (ACCVAL(I)) 80,90,80                                            PR201200
80    WRITE (IW,1240) (AIDCST(IU,I),IU=1,5),ANOM(I),DENSTY(I),CCEFEX(I),PR201210
     2ACCVAL(I)                                                          PR201220
      GO TO 100                                                          PR201230
90    WRITE (IW,1240) (AIDCST(IU,I),IU=1,5),ANOM(I),DENSTY(I),CCEFEX(I) PR201240
100   CONTINUE                                                           PR201250
C*****************************************************************************PR201260
C**   WRITE SECOND PAGE OF SERIES                                        **PR201270
C*****************************************************************************PR201280
110   CALL HEADPG                                                        PR201290
      CALL CHKLN (3)                                                     PR201300
      WRITE (IW,1150) ICALDS                                             PR201310
      CALL CHKLN (2)                                                     PR201320
      IF (N3.EQ.0) GO TO 210                                             PR201330
C*****************************************************************************PR201340
C**   OUTPUT IN ENGLISH UNITS                                            **PR201350
C**   JFLAG=1 POUNDS                                                     **PR201360
C**   JFLAG=2 MILLI-POUNDS                                               **PR201370
C**   JFLAG=3 MICRO-POUNDS                                               **PR201380
C*****************************************************************************PR201390
      JFLAG=1                                                            PR201400
      IF (PRTLBX(1).LT.0.001) GO TO 120                                  PR201410
      IF (PRTLBX(1).LT.1.0) JFLAG=2                                      PR201420
      GO TO 130                                                          PR201430
120   JFLAG=3                                                            PR201440
130   DO 170 I=1,NUNKN                                                   PR201450
      GO TO (140,150,160), JFLAG                                         PR201460
140   KTEMP(I)=INT(PRTLBX(I)+.5)                                         PR201470
      GO TO 170                                                          PR201480
150   KTEMP(I)=INT(1000.*PRTLBX(I)+.5)                                   PR201490
      GO TO 170                                                          PR201500
160   KTEMP(I)=INT(1000000.*PRTLBX(I)+.5)                                PR201510
170   CONTINUE                                                           PR201520
      GO TO (180,190,200), JFLAG                                         PR201530
180   WRITE (IW,1050) (KTEMP(I),I=1,NUNKN)                               PR201540
      GO TO 270                                                          PR201550
190   WRITE (IW,1060) (KTEMP(I),I=1,NUNKN)                               PR201560
      GO TO 270                                                          PR201570
200   WRITE (IW,1070) (KTEMP(I),I=1,NUNKN)                               PR201580
      GO TO 270                                                          PR201590
C*****************************************************************************PR201600
C**   OUTPUT IN METRIC                                                   **PR201610
C**   JFLAG=1 GRAMS                                                      **PR201620
C**   JFLAG=2 MILLIGRAMS                                                 **PR201630
C*****************************************************************************PR201640
210   JFLAG=1                                                            PR201650
      IF (ANOM(1).LT.1.0) JFLAG=2                                        PR201660
      DO 240 I=1,NUNKN                                                   PR201670
      GO TO (220,230), JFLAG                                             PR201680
220   KTEMP(I)=INT(ANOM(I)+.5)                                           PR201690
      GO TO 240                                                          PR201700
230   KTEMP(I)=INT(ANOM(I)*1000.+.5)                                     PR201710
240   CONTINUE                                                           PR201720
      GO TO (250,260), JFLAG                                             PR201730
250   WRITE (IW,1260) (KTEMP(I),I=1,NUNKN)                               PR201740
```

```
      GO TO 270                                                          PR201750
260   WRITE (IW,1270) (KTEMP(I),I=1,NUNKN)                               PR201760
C*****************************************************************PR201770
C**   SET UP AND PRINT DESIGN MATRIX                                  **PR201780
C*****************************************************************PR201790
270   DO 310 I=1,NOBS                                                   PR201800
      DO 300 J=1,NUNKN                                                   PR201810
      IF (DESMAT(J,I).EQ.0.0) GO TO 280                                  PR201820
      IF (DESMAT(J,I).EQ.1.0) GO TO 290                                  PR201830
      ITEMP(J)=KFD(12)                                                   PR201840
      GO TO 300                                                          PR201850
280   ITEMP(J)=KFD(11)                                                   PR201860
      GO TO 300                                                          PR201870
290   ITEMP(J)=KFD(15)                                                   PR201880
300   CONTINUE                                                           PR201890
      CALL CHKLN (1)                                                     PR201900
      WRITE (IW,1280) I,(ITEMP(J),J=1,NUNKN)                             PR201910
310   CONTINUE                                                           PR201920
      DO 340 J=1,NUNKN                                                   PR201930
      IF (ARSTIN(J).EQ.0.0) GO TO 320                                    PR201940
      IF (ARSTIN(J).EQ.1.0) GO TO 330                                    PR201950
      ITEMP(J)=KFD(12)                                                   PR201960
      GO TO 340                                                          PR201970
320   ITEMP(J)=KFD(11)                                                   PR201980
      GO TO 340                                                          PR201990
330   ITEMP(J)=KFD(15)                                                   PR202000
340   CONTINUE                                                           PR202010
      CALL CHKLN (1)                                                     PR202020
      WRITE (IW,1290) (ITEMP(J),J=1,NUNKN)                               PR202030
C*****************************************************************PR202040
C**   WRITE OBSERVATIONS AS READ                                      **PR202050
C*****************************************************************PR202060
      CALL CHKLN (3)                                                     PR202070
      WRITE (IW,1300)                                                    PR202080
      J=1                                                                PR202090
      CALL CHKLN (2)                                                     PR202100
      GO TO (350,390,400,450,470,  480), ITPOS                           PR202110
350   WRITE (IW,1310)                                                    PR202120
      DO 380 I=1,NOBS                                                    PR202130
      CALL CHKLN (1)                                                     PR202140
      IF (DS1(I).EQ.0.0) GO TO 360                                       PR202150
      WRITE (IW,1370) I,OBSERV(J),OBSERV(J+1),OBSERV(J+2)                PR202160
      GO TO 370                                                          PR202170
360   WRITE (IW,1370) I,OBSERV(J),OBSERV(J+1)                            PR202180
370   J=J+3                                                              PR202190
380   CONTINUE                                                           PR202200
      GO TO 510                                                          PR202210
C*****************************************************************PR202220
390   WRITE (IW,1320)                                                    PR202230
      GO TO 410                                                          PR202240
400   WRITE (IW,1330)                                                    PR202250
410   DO 440 I=1,NOBS                                                    PR202260
      CALL CHKLN (2)                                                     PR202270
      IF (DS1(I).EQ.0.0) GO TO 420                                       PR202280
      WRITE (IW,1380) I,OBSERV(J),OBSERV(J+1),OBSERV(J+2),OBSERV(J+3),OBPR202290
     2SERV(J+4),OBSERV(J+5),OBSERV(J+6),OBSERV(J+7),OBSERV(J+8)          PR202300
      GO TO 430                                                          PR202310
420   WRITE (IW,1390) I,OBSERV(J),OBSERV(J+1),OBSERV(J+2),OBSERV(J+3),OBPR202320
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     2SERV(J+4),CBSERV(J+5)                                                    PR202330
430    J=J+5                                                                   PR202340
440    CONTINUE                                                                PR202350
       GO TO 510                                                               PR202360
C*************************************************************************PR202370
450    WRITE (IW,1340)                                                         PR202380
       DO 460 I=1,NOBS                                                         PR202390
       CALL CHKLN (1)                                                          PR202400
       WRITE (IW,1390) I,CBSERV(J),OBSERV(J+1),OBSERV(J+2),OBSERV(J+3)         PR202410
       J=J+4                                                                   PR202420
460    CONTINUE                                                                PR202430
       GO TO 510                                                               PR202440
C*************************************************************************PR202450
470    WRITE (IW,1350)                                                         PR202460
       GO TO 490                                                               PR202470
480    WRITE (IW,1360)                                                         PR202480
490    JB=12                                                                   PR202490
       DO 500 I=1,NOBS                                                         PR202500
       CALL CHKLN (2)                                                          PR202510
       WRITE (IW,1400) I,(OBSERV(JA),JA=J,JB)                                  PR202520
       JB=JB+12                                                                PR202530
       J=J+12                                                                  PR202540
500    CONTINUE                                                                PR202550
510    IF (IFLAG) 530,540,520                                                  PR202560
C*************************************************************************PR202570
C**    RETURN IF MATRIX IS SINGULAR                                        **PR202580
C**         OR INVERSE IS IN ERROR                                         **PR202590
C*************************************************************************PR202600
520    CALL CHKLN (3)                                                          PR202610
       WRITE (IW,1410)                                                         PR202620
       RETURN                                                                  PR202630
530    CALL CHKLN (3)                                                          PR202640
       WRITE (IW,1420)                                                         PR202650
       M=NUNKN+2                                                               PR202660
       MA=M*M+1                                                                PR202670
       MB=MA+M*M-1                                                             PR202680
       ABC=FLOAT(MB-MA+1)/5.0+3.0                                              PR202690
       IABC=(MB-MA+1)/5+3                                                      PR202700
       IF (ABC.GT.FLOAT(IABC)) IABC=IABC+1                                     PR202710
       CALL CHKLN (IABC)                                                       PR202720
       WRITE (IW,1430) (Y(I),I=MA,MB)                                          PR202730
       MA=1                                                                    PR202740
       MB=M*M                                                                  PR202750
       ABC=FLOAT(MB-MA+1)/5.0+3.0                                              PR202760
       IABC=(MB-MA+1)/5+3                                                      PR202770
       IF (ABC.GT.FLOAT(IABC)) IABC=IABC+1                                     PR202780
       CALL CHKLN (IABC)                                                       PR202790
       WRITE (IW,1440) (Y(I),I=MA,MB)                                          PR202800
       MB=M*M                                                                  PR202810
       ABC=FLOAT(MB)/5.0+3.0                                                   PR202820
       IABC=MB/5+3                                                             PR202830
       IF (ABC.GT.FLOAT(IABC)) IABC=IABC+1                                     PR202840
       CALL CHKLN (IABC)                                                       PR202850
       WRITE (IW,1450) (B(I),I=1,MB)                                           PR202860
       RETURN                                                                  PR202870
C*************************************************************************PR202880
C**    WRITE THIRD PAGE OF SERIES                                          **PR202890
C*************************************************************************PR202900
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540   CALL HEADPG                                                        PR202910
      CALL CHKLN (3)                                                     PR202920
      WRITE (IW,1150) ICALDS                                             PR202930
      CALL CHKLN (5)                                                     PR202940
      WRITE (IW,1460) SWT,VSWT,CEXSWT,STAR                               PR202950
      CALL CHKLN (5)                                                     PR202960
      GO TO (550,550,580,610,610,  630), ITPOS                           PR202970
550   WRITE (IW,1470)                                                    PR202980
      DO 570 I=1,NOBS                                                    PR202990
      CALL CHKLN (1)                                                     PR203000
      IF (DS1(I).EQ.C.0) GO TO 560                                       PR203010
      WRITE (IW,1540) I,ICTSTR(I),A(I),DELTA(I),SWTPRT(I),DS1(I)         PR203020
      GO TO 570                                                          PR203030
560   WRITE (IW,1540) I,ICTSTR(I),A(I),DELTA(I),SWTPRT(I)                PR203040
570   CONTINUE                                                           PR203050
      GO TO 650                                                          PR203060
C*****************************************************************************PR203070
580   WRITE (IW,1480)                                                    PR203080
      CALL CHKLN (1)                                                     PR203090
      DO 600 I=1,NOBS                                                    PR203100
      IF (DS1(I).EQ.0.0) GO TO 590                                       PR203110
      WRITE (IW,1540) I,ICTSTR(I),A(I),DELTA(I),SWTPRT(I),ZERC(I),DS1(I)PR203120
      GO TO 600                                                          PR203130
590   WRITE (IW,1540) I,ICTSTR(I),A(I),DELTA(I),SWTPRT(I),ZERC(I)        PR203140
600   CONTINUE                                                           PR203150
      GO TO 650                                                          PR203160
C*****************************************************************************PR203170
610   WRITE (IW,1490)                                                    PR203180
      DO 620 I=1,NOBS                                                    PR203190
      CALL CHKLN (1)                                                     PR203200
      WRITE (IW,1540) I,ICTSTR(I),A(I),DELTA(I),SWTPRT(I),DRIFT(I),DS1(IPR203210
     2)                                                                  PR203220
620   CONTINUE                                                           PR203230
      GO TO 650                                                          PR203240
C*****************************************************************************PR203250
630   WRITE (IW,1500)                                                    PR203260
      DO 640 I=1,NOBS                                                    PR203270
      CALL CHKLN (1)                                                     PR203280
      WRITE (IW,1540) I,ICTSTR(I),A(I),DELTA(I),SWTPRT(I),DRIFT(I),ZERO(PR203290
     2I),DS1(I)                                                          PR203300
640   CONTINUE                                                           PR203310
650   IF (JSTAR.EQ.0) GO TO 660                                          PR203320
      CALL CHKLN (3)                                                     PR203330
      WRITE (IW,1510)                                                    PR203340
660   CALL CHKLN (6)                                                     PR203350
      IF (N3.EQ.0) GO TO 680                                             PR203360
C*****************************************************************************PR203370
C**   ENGLISH UNITS                                                     **PR203380
C*****************************************************************************PR203390
      WRITE (IW,1530)                                                    PR203400
      DO 670 I=1,NUNKN                                                   PR203410
      CALL CHKLN (1)                                                     PR203420
      FOBSCR=CBSCOR(I)                                                   PR203430
      WRITE (IW,1560) PRTLEX(I),FOBSCR,COMVOP(I),SERROR(I),TRISIG(I),TOTPR203440
     2UN(I)                                                              PR203450
670   CONTINUE                                                           PR203460
      GO TO 700                                                          PR203470
C*****************************************************************************PR203480
```

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C**   METRIC UNITS                                                    **PR203490
C*****************************************************************PR203500
680   WRITE (IW,1520)                                                  PR203510
      DO 690 I=1,NUNKN                                                 PR203520
      CALL CHKLN (1)                                                   PR203530
      FOBSCR=OBSCOR(I)                                                 PR203540
      WRITE (IW,1550) ANCM(I),FOBSCR,COMVOP(I),SERROR(I),TRISIG(I),TOTUNPR203550
     2(I)                                                              PR203560
690   CONTINUE                                                         PR203570
700   IF (ISWTCH.EQ.0) GO TO 710                                       PR203580
      CALL CHKLN (3)                                                   PR203590
      WRITE (IW,1570)                                                  PR203600
710   CALL CHKLN (3)                                                   PR203610
      WRITE (IW,1580) TEAR                                             PR203620
      XXXX=0.1*STDEBA                                                  PR203630
      XXXXX=ABS(ACORR-CORRES)                                          PR203640
      IF (XXXXX.LE.XXXX) GO TO 720                                     PR203650
      CALL CHKLN (7)                                                   PR203660
      WRITE (IW,1590) ACORR,CORRES                                     PR203670
720   IF (IROUT.EQ.0.0) GO TO 730                                      PR203680
      CALL CHKLN (6)                                                   PR203690
      WRITE (IW,1600) (IRSTOU(I),I=1,NUNKN)                            PR203700
      WRITE (IW,1610) TMSUM,VCLSUM,SERSUM,T3SIG                        PR203710
C*****************************************************************PR203720
C**   WRITE LAST PAGE OF SERIES  IF LINVAR NOT EQUAL TO ZERO          **PR203730
C*****************************************************************PR203740
730   IF (LINVAR.EQ.0) GO TO 930                                       PR203750
      CALL HEADPG                                                      PR203760
      CALL CHKLN (3)                                                   PR203770
      WRITE (IW,1150) ICALDS                                           PR203780
      CALL CHKLN (3)                                                   PR203790
      WRITE (IW,1620)                                                  PR203800
      CALL CHKLN (1)                                                   PR203810
      IF (N3.EQ.0) GO TO 770                                           PR203820
C*****************************************************************PR203830
C**   ENGLISH UNITS                                                  **PR203840
C*****************************************************************PR203850
      GO TO (740,750,760), JFLAG                                       PR203860
740   WRITE (IW,1080)                                                  PR203870
      GO TO 800                                                        PR203880
750   WRITE (IW,1090)                                                  PR203890
      GO TO 800                                                        PR203900
760   WRITE (IW,1100)                                                  PR203910
      GO TO 800                                                        PR203920
C*****************************************************************PR203930
C**   METRIC UNITS                                                   **PR203940
C*****************************************************************PR203950
770   GO TO (780,790), JFLAG                                           PR203960
780   WRITE (IW,1630)                                                  PR203970
      GO TO 800                                                        PR203980
790   WRITE (IW,1640)                                                  PR203990
800   CALL CHKLN (1)                                                   PR204000
      WRITE (IW,1650) (KTEMP(I),I=1,NUNKN)                             PR204010
      DO 840 I=1,LINVAR                                                PR204020
      JTEMP(I)=0                                                       PR204030
      DO 830 J=1,NUNKN                                                 PR204040
      JTEMP(I)=JTEMP(I)+KTEMP(J)*INT(ALCOM(J,I))                       PR204050
      IF (ALCOM(J,I).EQ.0.0) GO TO 810                                 PR204060
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      IF (ALCOM(J,I).EQ.1.0) GO TO 820                                  PR204070
      ITEMP(J)=KFD(12)                                                  PR204080
      GO TO 830                                                         PR204090
810   ITEMP(J)=KFD(11)                                                  PR204100
      GO TO 830                                                         PR204110
820   ITEMP(J)=KFD(15)                                                  PR204120
830   CONTINUE                                                          PR204130
      CALL CHKLN (1)                                                    PR204140
      WRITE (IW,1660) JTEMP(I),(ITEMP(K),K=1,NUNKN)                     PR204150
840   CONTINUE                                                          PR204160
      CALL CHKLN (8)                                                    PR204170
      WRITE (IW,1670)                                                   PR204180
      WRITE (IW,1680)                                                   PR204190
      CALL CHKLN (2)                                                    PR204200
      IF (N3.EQ.0) GO TO 880                                            PR204210
      GO TO (850,860,870), JFLAG                                        PR204220
850   WRITE (IW,1110)                                                   PR204230
      GO TO 910                                                         PR204240
860   WRITE (IW,1120)                                                   PR204250
      GO TO 910                                                         PR204260
870   WRITE (IW,1130)                                                   PR204270
      GO TO 910                                                         PR204280
880   GO TO (890,900), JFLAG                                            PR204290
890   WRITE (IW,1690)                                                   PR204300
      GO TO 910                                                         PR204310
900   WRITE (IW,1700)                                                   PR204320
910   DO 920 I=1,LINVAR                                                 PR204330
      CALL CHKLN (1)                                                    PR204340
      WRITE (IW,1710) JTEMP(I),CORRSA(I),SERSA(I),SIG3SA(I),UNCSA(I)    PR204350
920   CONTINUE                                                          PR204360
C*****************************************************************************PR204370
C**   WRITE LAST PAGE OF SERIES                                          **PR204380
C*****************************************************************************PR204390
930   CALL HEADPG                                                       PR204400
      CALL CHKLN (2)                                                    PR204410
      WRITE (IW,1720) ALCADP,IBREST                                     PR204420
      CALL CHKLN (3)                                                    PR204430
      WRITE (IW,1150) ICALDS                                            PR204440
      CALL CHKLN (9)                                                    PR204450
      WRITE (IW,1730) OBSTD,STDERA,NDGFR,FRATIO                         PR204460
C*****************************************************************************PR204470
C**   COMPUTE F - VALUE                                                  **PR204480
C*****************************************************************************PR204490
      PRETST=6.64                                                       PR204500
      CALL CHKLN (4)                                                    PR204510
      IF (NDGFR.EQ.1) GO TO 940                                         PR204520
      ANDGFR=NDGFR                                                      PR204530
      PRETST=(1.0-2.0/(9.*ANDGFR)+2.32635*SQRT(2.0/(9.0*ANDGFR)))**3    PR204540
940   IF (FRATIO.GT.PRETST) GO TO 950                                   PR204550
      WRITE (IW,1740) PRETST                                            PR204560
      GO TO 960                                                         PR204570
950   WRITE (IW,1750)                                                   PR204580
      WRITE (IW,1760) PRETST                                            PR204590
      WRITE (IW,1750)                                                   PR204600
      ITST=0                                                            PR204610
960   DO 970 I=1,NUNKN                                                  PR204620
970   ITEMP(I)=ACKSTD(I)                                                PR204630
      CALL CHKLN (3)                                                    PR204640
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      WRITE (IW,1810)                                                    PR204650
      CALL CHKLN (1)                                                     PR204660
      WRITE (IW,1180) (ITEMP(I),I=1,NUNKN)                               PR204670
      CALL CHKLN (1)                                                     PR204680
      WRITE (IW,1190) ICKUSD                                             PR204690
      CALL CHKLN (1)                                                     PR204700
      WRITE (IW,1200) V2TAU                                              PR204710
      CALL CHKLN (6)                                                     PR204720
      WRITE (IW,1770) OBCOCK,OESCK,TVAL                                  PR204730
      CALL CHKLN (1)                                                     PR204740
      IF (OBSCK.NE.0.0) GO TO 980                                        PR204750
      WRITE (IW,1820)                                                    PR204760
980   IF (ABS(TVAL).GE.3.) GO TO 990                                     PR204770
      CALL CHKLN (3)                                                     PR204780
      WRITE (IW,1780)                                                    PR204790
      GO TO 1030                                                         PR204800
990   WRITE (IW,1750)                                                    PR204810
      ITST=0                                                             PR204820
      YXYX=0.0                                                           PR204830
      DO 1000 I=1,NUNKN                                                  PR204840
1000  YXYX=YXYX+(ACKSTD(I)*SERRCR(I))                                    PR204850
      XYYX=ABS(TVAL)-(YXYX/OBSCK)                                        PR204860
      CALL CHKLN (3)                                                     PR204870
      IF (XYYX.GE.3.) GO TO 1010                                         PR204880
      WRITE (IW,1790)                                                    PR204890
      GO TO 1020                                                         PR204900
1010  WRITE (IW,1800)                                                    PR204910
      ITST=0                                                             PR204920
1020  CONTINUE                                                           PR204930
      CALL CHKLN (16)                                                    PR204940
      WRITE (IW,1750)                                                    PR204950
1030  WRITE (IW,1210) T1P,T2P,TBAR,P1P,P2P,PBAR,H1P,H2P,HBAR,RHOAB,RHOAAPR204960
     2,RHOA,CT1,CT2,CP1,CP2,CH1,CH2,CT1P,CT2P,OP1P,OP2P,OH1P,OH2P        PR204970
      DIFT=T2P-T1P                                                       PR204980
      DIFP=P2P-P1P                                                       PR204990
      DIFH=H2P-H1P                                                       PR205000
C*************************************************************************PR205010
C**   PUNCH CONTROL DATA RECORDS                                        **PR205020
C*************************************************************************PR205030
      NTOF=NTOP*ITST                                                     PR205040
      IF (ITST.EQ.0) RETURN                                              PR205050
      WRITE (ITMP) (IDATE(K),K=1,3),IBREST,ICKUSD,OBCOCK,IBAL,OESTD,NDGFPR205060
     2R,ICALDS,TBAR,DIFT,PBAR,DIFP,HBAR,DIFH,RHOA,IOP                    PR205070
      NTOF=NTOP+1                                                        PR205080
      RETURN                                                             PR205090
C*************************************************************************PR205100
C**   FORMAT STATEMENTS                                                 **PR205110
C*************************************************************************PR205120
1040  FORMAT (1X,13HREPORT VECTOR,1X,15I5)                               PR205130
1050  FORMAT (6X,3H LB/6X,15I6)                                          PR205140
1060  FORMAT (6X,9H MILLI-LB/6X,15I6)                                    PR205150
1070  FORMAT (6X,9H MICRO-LB/6X,15I6)                                    PR205160
1080  FORMAT (2X,4H(LB),6X,2HLB)                                         PR205170
1090  FORMAT (1X,8HMILLI-LB,6X,8HMILLI-LB)                               PR205180
1100  FORMAT (1X,8HMICRO-LB,6X,8HMICRO-LB)                               PR205190
1110  FORMAT (2X,4H(LB),6X,4H(MG),7X,4H(MG),10X,4H(MG),10X,4H(MG)/)      PR205200
1120  FORMAT (1X,10H(MILLI-LB),3X,4H(MG),7X,4H(MG),10X,4H(MG),10X,4H(MG)PR205210
     2/)                                                                 PR205220
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1130  FORMAT (1X,10H(MICRO-LB),3X,4H(MG),7X,4H(MG),10X,4H(MG),10X,4H(MG)PR205230
     2/)                                                                PR205240
1140  FORMAT (50H ACCEPTED WITHIN STANDARD DEVIATION OF THE PROCESS,2X, PR205250
     2 F13.5,3H MG/51H ACCEPTED BETWEEN STANDARD DEVIATION OF THE PRCCESPR205260
     3S,1X,F13.5,3H MG)                                                 PR205270
1150  FORMAT (//20H CALIERATION DESIGN ,I4)                             PR205280
1160  FORMAT (17H RESTRAINT VECTOR,1X,15I5)                             PR205290
1170  FORMAT (31H MASS CORRECTION OF RESTRAINT  ,31X,F13.5,3H MG/       PR205300
     2 46H VOLUME OF WEIGHTS BEING USED IN RESTRAINT AT F6.2,3H C ,7X,  PR205310
     3 F13.5,4H CM3/36H SYSTEMATIC ERROR IN THE RESTRAINT  ,26X,F13.5,  PR205320
     4 3H MG/65H 3 STANDARD DEVIATION LIMIT FOR RANDOM ERROR AFFECTING RPR205330
     5ESTRAINT ,F10.5,3H MG//)                                          PR205340
1180  FORMAT (22H CHECK STANDARD VECTOR,1X,15I5)                        PR205350
1190  FORMAT (22H CHECK STANDARD USED  ,I4)                             PR205360
1200  FORMAT (44H ACCEPTED MASS CORRECTION OF CHECK STANDARD ,F13.5,    PR205370
     2 3H MG)                                                           PR205380
1210  FORMAT (//16H TEST CONDITIONS,29X,6HBEFORE,7X,5HAFTER,7X,7HAVERAGEPR205390
     2/36H CORRECTED TEMPERATURE IN DEGREES C ,3F13.2/                  PR205400
     3 28H CORRECTED PRESSURE IN MM HG,9X,3F13.3/                       PR205410
     4 30H CORRECTED HUMIDITY IN PERCENT,6X,3F13.2/                     PR205420
     5 31H COMPUTED AIR DENSITY IN MG/CM3,7X,3F13.4/                    PR205430
     6 23H TEMPERATURE CORRECTION,14X,2F13.3/20H PRESSURE CORRECTION,17XPR205440
     7,2F13.3/20H HUMIDITY CORRECTION,16X,2F13.2/                       PR205450
     8 34H OBSERVED TEMPERATURE IN DEGREES C,2X,2F13.2/                 PR205460
     9 28H OBSERVED PRESSURE IN MM HG ,9X,2F13.3/                       PR205470
     * 30H OBSERVED HUMIDITY IN PERCENT ,6X,2F13.2//)                   PR205480
1220  FORMAT (4X,13HWEIGHTS BEING,5X,7HNOMINAL,6X,7HDENSITY,5X,         PR205490
     2 11HCOEFFICIENT,3X,8HACCEPTED/8X,6HTESTED,7X,8HVALUE LB,3X,      PR205500
     3 12HG/CM3 AT 20C,2X,12HOF EXPANSION,2X,13HCORRECTION MG/)         PR205510
1230  FORMAT (1X,5A3,1X,F12.7,3X,F7.4,6X,F7.6,3X,F13.5)                 PR205520
1240  FORMAT (1X,5A3,1X,F12.4,3X,F7.4,6X,F7.6,3X,F13.5)                 PR205530
1250  FORMAT (4X,13HWEIGHTS BEING,5X,7HNOMINAL,6X,7HDENSITY,5X,         PR205540
     2 11HCOEFFICIENT,3X,8HACCEPTED/8X,6HTESTED,7X,8HVALUE G ,3X,      PR205550
     3 12HG/CM3 AT 20C,2X,12HOF EXPANSION,2X,13HCORRECTION MG/)         PR205560
1260  FORMAT (6X,6H GRAMS/6X,15I6)                                      PR205570
1270  FORMAT (6X,3H MG/6X,15I6)                                         PR205580
1280  FORMAT (3H A ,I2,1X,15(5X,A1))                                    PR205590
1290  FORMAT (3H R 3X,15(5X,A1))                                        PR205600
1300  FORMAT (//26H OBSERVATIONS IN DIVISIONS)                          PR205610
1310  FORMAT (39H SINGLE SUBSTITUTION SINGLE PAN BALANCE/)              PR205620
1320  FORMAT (36H SINGLE SUBSTITUTION TWO PAN BALANCE/)                 PR205630
1330  FORMAT (37H SINGLE TRANSPOSITION TWO PAN BALANCE/)                PR205640
1340  FORMAT (36H DOUBLE SUBSTITUTION ONE PAN BALANCE/)                 PR205650
1350  FORMAT (36H DOUBLE SUBSTITUTION TWO PAN BALANCE/)                 PR205660
1360  FORMAT (37H DOUBLE TRANSPOSITION TWO PAN BALANCE/)                PR205670
1370  FORMAT (3H A ,I2,1X,3F11.4)                                       PR205680
1380  FORMAT (3H A ,I2,1X,6F11.4/6X,3F11.4)                             PR205690
1390  FORMAT (3H A ,I2,1X,4F11.4)                                       PR205700
1400  FORMAT (3H A ,I2,1X,6F11.4/6X,6F11.4)                             PR205710
1410  FORMAT (//19H MATRIX IS SINGULAR)                                 PR205720
1420  FORMAT (//17H1ERROR IN INVERSE)                                   PR205730
1430  FORMAT (//4H A =/(5E16.8))                                        PR205740
1440  FORMAT (//12H A(INVERSE)=/(5E16.8))                               PR205750
1450  FORMAT (//15H I-AA(INVERSE)=/(5E16.8))                            PR205760
1460  FORMAT (/19H SENSITIVITY WEIGHT/5H MASS,2X,F13.5,3H MG/7H VOLUME, PR205770
     2 2X,F13.5,12H CM3 AT 20 C/25H COEFFICIENT OF EXPANSION,2X,F8.6/5X,PR205780
     3 11HS*=S-PV(S)=,1X,F13.5,3H MG)                                   PR205790
1470  FORMAT (/36X,7HAVERAGE,6X,8HOBSERVED/13X,4HA(I),6X,8HDELTA(I),3X, PR205800
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     2 11HSENSITIVITY,2X,11HSENSITIVITY/13X,4H(MG),8X,4H(MG),6X,          PR205810
     3 8H(MG/DIV),6X,8H(MG/DIV/)                                          PR205820
1480  FORMAT (/35X,7HAVERAGE,16X,8HOBSERVED/13X,4HA(I),6X,8HDELTA(I),3X,PR205830
     2 11HSENSITIVITY,4X,7HZERO(I),2X,11HSENSITIVITY/13X,4H(MG),9X,       PR205840
     3 4H(MG),5X,8H(MG/DIV),6X,5H(DIV),6X,8H(MG/DIV)/)                    PR205850
1490  FORMAT (/37X,7HAVERAGE,16X,8HOBSERVED/13X,4HA(I),5X,8HDELTA(I),5X,PR205860
     2 11HSENSITIVITY,2X,8HDRIFT(I),2X,11HSENSITIVITY/13X,4H(MG),7X,      PR205870
     3 4H(MG),8X,8H(MG/DIV),6X,4H(MG),6X,8H(MG/DIV)/)                     PR205880
1500  FORMAT (/37X,7HAVERAGE,27X,8HOBSERVED/13X,4HA(I),6X,8HDELTA(I),4X,PR205890
     2 11HSENSITIVITY,2X,8HDRIFT(I),3X,7HZERO(I),3X,11HSENSITIVITY/13X,  PR205900
     3 4H(MG),8X,4H(MG),7X,8H(MG/DIV),5X,4H(MG),6X,5H(DIV),6X,8H(MG/DIV)PR205910
     4/)                                                                  PR205920
1510  FORMAT (/6X,64H* OBSERVED DEFLECTION IS GREATER THAN OR EQUAL TO OPR205930
     2NE FOURTH THE/8X,22HSENSITIVITY DEFLECTION)                         PR205940
1520  FORMAT (//31X,6HVOLUME,5X,10HSYSTEMATIC,3X,6H3 S.D.,3X,             PR205950
     2 11HUNCERTAINTY/5X,4HITEM,8X,10HCORRECTION,4X,6H(AT T),8X,,5HERRORPR205960
     3,6X,5HLIMIT,6X,5HLIMIT/6X,3H(G),12X,4H(MG),7X,5H(CM3),9X,4H(MG),7XPR205970
     4,4H(MG),7X,4H(MG)/)                                                 PR205980
1530  FORMAT (//31X,6HVOLUME,5X,10HSYSTEMATIC,3X,6H3 S.D.,3X,             PR205990
     2 11HUNCERTAINTY/5X,4HITEM,8X,10HCORRECTION,4X,6H(AT T),8X,5HERROR,PR206000
     3 6X,5HLIMIT,6X,5HLIMIT/5X,4H(LB),12X,4H(MG),7X,5H(CM3),9X,4H(MG),  PR206010
     4 7X,4H(MG),7X,4H(MG)/)                                              PR206020
1540  FORMAT (3H A ,I2,1X,A1,6F12.5)                                       PR206030
1550  FORMAT (1X,F12.4,2F13.5,3F11.5)                                      PR206040
1560  FORMAT (1X,F12.7,2F13.5,3F11.5)                                      PR206050
1570  FORMAT (/25H STOPPED AT 10 ITERATIONS/)                              PR206060
1580  FORMAT (/15H TEMPERATURE T=,F6.2,3H  C/)                             PR206070
1590  FORMAT (1X,72H************************************************PR206080
     2********************/1X,                                            PR206090
     3 72HINPUT ERROR IN RESTRAINT. CHECK RESTRAINT VECTOR, NOMINAL VALUPR206100
     4E, DENSITY/1X,                                                      PR206110
     5 72HAND COEFFICIENT OF EXPANSION IN THIS AND PREVIOUS SERIES.       PR206120
     6           /2X,30H INPUT CORRECTION OF RESTRAINT,4X,F11.4,3H MG/2X,PR206130
     7 33H COMPUTED CORRECTION OF RESTRAINT,1X,F11.4,3H MG/1X,            PR206140
     8 72H************************************************************PR206150
     9**********/)                                                       PR206160
1600  FORMAT (31H RESTRAINT FOR FOLLOWING SERIES/17H RESTRAINT VECTOR,1XPR206170
     2,15I5)                                                              PR206180
1610  FORMAT (16H MASS CORRECTION,17X,F13.5,3H MG/15H VOLUME AT 20 C,18XPR206190
     2,F13.5,4H CM3/17H SYSTEMATIC ERROR,16X,F13.5,3H MG/                 PR206200
     3 27H 3 STANDARD DEVIATION LIMIT,6X,F13.5,3H MG)                     PR206210
1620  FORMAT (//3X,3HSUM,6X,40HWEIGHTS USED FOR THE LINEAR COMBINATIONS)PR206220
1630  FORMAT (3X,3H(G),6X,5HGRAMS)                                         PR206230
1640  FORMAT (2X,4H(MG),6X,2HMG)                                           PR206240
1650  FORMAT (6X,15I5)                                                     PR206250
1660  FORMAT (1X,I5,15(4X,A1))                                             PR206260
1670  FORMAT (//10X,                                                       PR206270
     2 52HVALUES AND UNCERTAINTIES FOR COMBINATIONS OF WEIGHTS/1X,         PR206280
     3 61H(UNCERTAINTY IS 3 STANDARD DEVIATION LIMIT PLUS ALLOWANCE FOR/PR206290
     4 19H SYSTEMATIC ERROR.))                                            PR206300
1680  FORMAT (/39X,6H3 S.D.,5X,11HUNCERTAINTY/3X,3HSUM,8X,4HCORR,4X,      PR206130
     2 10HSYSTEMATIC,7X,5HERROR,8X,5HLIMIT)                               PR206320
1690  FORMAT (3X,3H(G),8X,4H(MG),7X,4H(MG),10X,4H(MG),10X,4H(MG)/)         PR206330
1700  FORMAT (2X,4H(MG),8X,4H(MG),7X,4H(MG),10X,4H(MG),10X,4H(MG)/)        PR206340
1710  FORMAT (1X,I5,4F13.5)                                                PR206350
1720  FORMAT (13H MAXIMUM LOAD,F15.4,2H G/1X,                              PR206360
     2 25HSTARTING RESTRAINT NUMBER,2X,I2)                                PR206370
1730  FORMAT (//18H PRECISION CONTROL///                                   PR206380
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     2 43H OBSERVED STANDARD DEVIATION OF THE PROCESS,F12.5,4H  MG/      PR206390
     3 43H ACCEPTED STANDARD DEVIATION OF THE PROCESS,F12.5,4H  MG/      PR206400
     4 19H DEGREES OF FREEDOM,I5/8H F RATIO,F12.3)                       PR206410
1740  FORMAT (/21H F RATIO IS LESS THAN,F6.2,                            PR206420
     2 40H (CRITICAL VALUE FOR PROBABILITY = .01)./                      PR206430
     3 48H THEREFORE THE STANDARD DEVIATION IS IN CONTROL./)             PR206440
1750  FORMAT (80H **********************************************************PR206450
     2**************************)                                        PR206460
1760  FORMAT (24H F RATIO IS GREATER THAN,F6.2,                          PR206470
     2 40H (CRITICAL VALUE FOR PROBABILITY = .01)./                      PR206480
     3 52H THEREFORE THE STANDARD DEVIATION IS NOT IN CONTROL.)          PR206490
1770  FORMAT (38H OBSERVED CORRECTION OF CHECK STANDARD,F19.5,3H MG/     PR206500
     2 46H STANDARD DEVIATION OF THE OBSERVED CORRECTION,F11.5,3H MG/    PR206510
     3 8H T VALUE,F8.2///)                                              PR206520
1780  FORMAT (36H ABSOLUTE VALUE OF T IS LESS THAN 3./                   PR206530
     2 40H THEREFORE CHECK STANDARD IS IN CONTROL./)                     PR206540
1790  FORMAT (1X,72HALTHOUGH THE ABSOLUTE VALUE OF T IS GREATER THAN OR PR206550
     2EQUAL TO 3 ,         /1X,                                         PR206560
     3 72HTHE T VALUE CORRECTED FOR SYSTEMATIC ERROR IS LESS THAN 3,    PR206570
     4          /1X,                                                    PR206580
     5 72HTHEREFORE THE CHECK STANDARD IS IN CONTROL .                  PR206590
     6          )                                                       PR206600
1800  FORMAT (1X,72HALTHOUGH THE ABSOLUTE VALUE OF T IS GREATER THAN OR PR206610
     2EQUAL TO 3 ,         /1X,                                         PR206620
     3 72HTHE DIFFERENCE IS STILL SIGNIFICANT AFTER ALLOWANCE FOR SYSTEMPR206630
     4ATIC      /1X,                                                    PR206640
     5 72HERROR , THEREFORE THE CHECK STANDARD IS NOT IN CONTROL .      PR206650
     6          )                                                       PR206660
1810  FORMAT (//)                                                       PR206670
1820  FORMAT (52H T VALUE EQUALS ZERO--CHECK STANDARD VECTOR IS ZERO.)  PR206680
      END                                                               PR206690
--- PGCONT SUBPROGRAM ---
      SUBROUTINE PGCONT                                                 PGC00090
C*************************************************************************PGC00020
C**   SUBROUTINE OF THE NATIONAL BUREAU OF STANDARDS MASS CALIBRATION **PGC00030
C**   PROGRAM  VERSION OF SEPT. 10,1971    WRITTEN BY R.C.RAYFORD      **PGC00040
C**   AND MRS.R.N.VARNER                                               **PGC00050
C**   MODIFIED BY R. N. VARNER SEPT 1979                               **PGC00060
C*************************************************************************PGC00070
C**   SUBROUTINE TO WRITE CONTINUATION PAGE                            **PGC00080
C*************************************************************************PGC00090
C**   DIMENSION FOR COMMON /PRT1/ VARIABLES                            **PGC00100
C*************************************************************************PGC00110
      DIMENSION B1(72),B2(72),B3(72),B4(72),B5(72),B6(72),B7(72),       PGC00120
     2 IDATE(3)                                                         PGC00130
C*************************************************************************PGC00140
C**   DIMENSION FOR COMMON /INPUT/ VARIABLES                           **PGC00150
C*************************************************************************PGC00160
      DIMENSION AIDCST(5,15),ANOM(15),DENSTY(15),COEFEX(15),ACCVAL(15), PGC00170
     2 ARSTIN(15),ACKSTD(15),IRSTCU(15),IPRNT(15),DESMAT(15,50),        PGC00180
     3 OBSERV(600),ALCOM(15,20)                                         PGC00190
C*************************************************************************PGC00200
C**   LABELED COMMON                                                   **PGC00210
C*************************************************************************PGC00220
      COMMON /PRT1/ B1,B2,B3,B4,B5,B6,B7,RANERR,SYSERR,TNOM,L1,L2,L3,L4,PGC00230
     2 L5,L6,IDATE,IBREST                                               PGC00240
      COMMON /PRT2/ IPAGE,NOSER,IPGCT                                   PGC00250
      COMMON /INPUT/ TBAR,PBAR,FBAR,STDEBA,SWT,VSWT,CEXSWT,AIDCST,ANOM, PGC00260
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     2 DENSTY,COEFEX,ACCVAL,ARSTIN,ACKSTD,DESMAT,CBSERV,VARBAL,ALCOM,T1PPGC00270
     3,T2P,P1P,P2P,H1P,H2P,CP1,CP2,CT1,CT2,CH1,CH2,OT1P,OT2P,OP1P,OP2P, PGC00280
     4 OH1P,OH2P,IOP,IBAL,NOBS,NUNKN,IRSTOU,IPRNT,ITPOS,ICKUSD,ICALDS,  PGC00290
     5 LINVAR,N3,N4                                                     PGC00300
      COMMON /UNITIO/ IR,IW,IP,IPL,ITMP                                 PGC00310
      WRITE (IW,30) IPAGE                                               PGC00320
C*****************************************************************PGC00330
C**   NOSER IS SET EQUAL TO 200 IN FINPRT                           **PGC00340
C*****************************************************************PGC00350
      IF (NOSER.LT.200) GO TO 10                                        PGC00360
      IPAGE=IPAGE+1                                                     PGC00370
      WRITE (IW,50) (B1(K),K=1,65),IPAGE,(B2(K),K=1,65),(IDATE(K),K=1,3)PGC00380
     2,(B3(K),K=1,65)                                                   PGC00390
      GO TO 20                                                          PGC00400
10    IPAGE=IPAGE+1                                                     PGC00410
      WRITE (IW,40) (B1(K),K=1,65),IPAGE,(B2(K),K=1,65),NOSER,(B3(K),K=1PGC00420
     2,65),(IDATE(K),K=1,3)                                             PGC00430
20    IPGCT=6                                                           PGC00440
      RETURN                                                            PGC00450
C*****************************************************************PGC00460
C**   FORMAT STATEMENTS                                             **PGC00470
C*****************************************************************PGC00480
30    FORMAT (1H1,30X,19HCONTINUED FROM PAGE13)                         PGC00490
40    FORMAT (1H ,65A1,4HPAGE,I3/1X,65A1,6HSERIES,I2/1X,65A1,I2,1H/,I2, PGC00500
     2 1H/,I2//)                                                        PGC00510
50    FORMAT (1X,65A1,4HPAGE,I3/1X,65A1,I2,1H/,I2,1H/,I2/1X,65A1//)     PGC00520
      END                                                               PGC00530
--- HEADPG SUBPROGRAM ---
      SUBROUTINE HEADPG                                                 HDP00010
C*****************************************************************HDP00020
C**   SUBROUTINE TO PRINT PAGE HEADINGS                             **HDP00030
C**   ADDED BY R. N. VARNER SEPT 1979                               **HDP00040
C*****************************************************************HDP00050
C**   DIMENSION FOR COMMON /PRT1/ VARIABLES                         **HDP00060
C*****************************************************************HDP00070
      DIMENSION B1(72),B2(72),B3(72),B4(72),B5(72),B6(72),B7(72),       HDP00080
     2 IDATE(3)                                                         HDP00090
C*****************************************************************HDP00100
C**   DIMENSION FOR COMMON /INPUT/ VARIABLES                        **HDP00110
C*****************************************************************HDP00120
      DIMENSION AIDCST(5,15),ANCM(15),DENSTY(15),COEFEX(15),ACCVAL(15), HDP00130
     2 ARSTIN(15),ACKSTD(15),IRSTOU(15),IPRNT(15),DESMAT(15,50),        HDP00140
     3 CBSERV(600),ALCOM(15,20)                                         HDP00150
C*****************************************************************HDP00160
C**   LABELED COMMON                                                **HDP00170
C*****************************************************************HDP00180
      COMMON /PRT1/ B1,B2,B3,B4,B5,B6,B7,RANERR,SYSERR,TNOM,L1,L2,L3,L4,HDP00190
     2 L5,L6,IDATE,IEREST                                               HDP00200
      COMMON /PRT2/ IPAGE,NOSER,IPGCT                                   HDP00210
      COMMON /INPUT/ TBAR,PBAR,HBAR,STDEBA,SWT,VSWT,CEXSWT,AIDCST,ANCM, HDP00220
     2 DENSTY,COEFEX,ACCVAL,ARSTIN,ACKSTD,DESMAT,CBSERV,VARBAL,ALCOM,T1PHDP00230
     3,T2P,P1P,P2P,H1P,H2P,CP1,CP2,CT1,CT2,CH1,CH2,OT1P,OT2P,OP1P,OP2P, HDP00240
     4 OH1P,OH2P,IOP,IBAL,NOBS,NUNKN,IRSTOU,IPRNT,ITPOS,ICKUSD,ICALDS,  HDP00250
     5 LINVAR,N3,N4                                                     HDP00260
      COMMON /UNITIO/ IR,IW,IP,IPL,ITMP                                 HDP00270
      IPAGE=IPAGE+1                                                     HDP00280
      WRITE (IW,10) (B1(K),K=1,65),IPAGE,(B2(K),K=1,65),NOSER,(B3(K),K=1HDP00290
     2,65),(IDATE(K),K=1,3),(B7(K),K=1,18),IBAL,ICP                     HDP00300
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      IPGCT=8                                                          HDP00310
      RETURN                                                           HDP00320
10    FORMAT (1H1,65A1,4HPAGE,I3/1X,65A1,6HSERIES,I2/1X,65A1,I2,1H/I2,  HDP00330
     2 1H/I2/1X,11HTEST NUMBER,2X,18A1///8H BALANCE,1X,I3/9H OPERATOR,1XHDP00340
     3,I2)                                                             HDP00350
      END                                                              HDP00360
--- FINPRT SUBPROGRAM ---
      SUBROUTINE FINPRT                                                FPR00010
C*****************************************************************FPR00020
C**   SUBROUTINE OF THE NATIONAL BUREAU OF STANDARDS MASS CALIBRATION **FPR00030
C**   PROGRAM  VERSION OF SEPT. 10,1971    WRITTEN BY R.C.RAYBOLD     **FPR00040
C**   AND MRS.R.N.VARNER                                             **FPR00050
C**   MODIFIED BY R. N. VARNER SEPT 1979                             **FPR00060
C*****************************************************************FPR00070
C**   SUBROUTINE TO PRINT  REPORT                                    **FPR00080
C*****************************************************************FPR00090
C**   DIMENSION FOR COMMON /REPRT/ VARIABLES                         **FPR00100
C*****************************************************************FPR00110
      DIMENSION AITEM(5,50),APPMAS(50),TRMASS(50),UNCERT(50),VOLPRT(50),FPR00120
     2 COEPRT(50),CORRB(50)                                           FPR00130
C*****************************************************************FPR00140
C**   DIMENSION FOR SUBROUTINE FINPRT                                **FPR00150
C*****************************************************************FPR00160
      DIMENSION TRMASX(15),AAAMAS(13),BBBMAS(13),NNP(50),TEMPAR(50)    FPR00170
      DIMENSION IAP(9),TAP(9)                                          FPR00180
C*****************************************************************FPR00190
C**   DIMENSION FOR COMMON /PRT1/ VARIABLES                          **FPR00200
C*****************************************************************FPR00210
      DIMENSION B1(72),B2(72),B3(72),B4(72),B5(72),B6(72),B7(72),      FPR00220
     2 IDATE(3)                                                       FPR00230
C*****************************************************************FPR00240
C**   DIMENSION FOR COMMON /INPUT/ VARIABLES                         **FPR00250
C*****************************************************************FPR00260
      DIMENSION AIDCST(5,15),ANOM(15),DENSTY(15),COEFEX(15),ACCVAL(15), FPR00270
     2 ARSTIN(15),ACKSTD(15),IRSTCU(15),IPRNT(15),DESMAT(15,50),       FPR00280
     3 OBSERV(600),ALCOM(15,20)                                       FPR00290
C*****************************************************************FPR00300
C**   LABELED COMMON                                                 **FPR00310
C*****************************************************************FPR00320
      COMMON /PRT1/ B1,B2,B3,B4,B5,B6,B7,RANERR,SYSERR,TNOM,L1,L2,L3,L4,FPR00330
     2 L5,L6,IDATE,IBREST                                             FPR00340
      COMMON /PRT2/ IPAGE,NOSER,IPGCT                                  FPR00350
      COMMON /REPRT/ TRMASS,APPMAS,CORRB,AITEM,UNCERT,VOLPRT,COEPRT,NPRTFPR00360
      COMMON /INPUT/ TEAR,PBAR,HEAR,STDEBA,SWT,VSWT,CEXSWT,AIDCST,ANOM, FPR00370
     2 DENSTY,COEFEX,ACCVAL,ARSTIN,ACKSTD,DESMAT,OBSERV,VARBAL,ALCOM,T1PFPR00380
     3,T2P,P1P,P2P,H1P,H2P,CP1,CP2,CT1,CT2,CH1,CH2,OT1P,OT2P,CP1P,OP2P, FPR00390
     4 OH1P,CH2P,IOP,IEAL,NOES,NUNKN,IRSTCU,IPRNT,ITPOS,ICKUSD,ICALDS,  FPR00400
     5 LINVAR,N3,N4                                                   FPR00410
      COMMON /UNITIC/ IR,IW,IP,IPL,ITMP                                FPR00420
      COMMON /PCHCUT/ NTCP                                             FPR00430
C*****************************************************************FPR00440
C**       TYPE STATEMENTS                                           **FPR00450
C*****************************************************************FPR00460
      DOUBLE PRECISION TRMASS,APPMAS,CORRB,TEMPAR                      FPR00470
      INTEGER TRMASX,BBBMAS,AAAMAS                                     FPR00480
      IF (NTCP.NE.NOSER) GO TO 20                                      FPR00490
      IFLAG=999                                                        FPR00500
      WRITE (ITMP) IFLAG,(IAP(I),I=2,5),TAP(1),IAP(6),TAP(2),IAP(7),IAP(FPR00510
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     28),(TAP(I),I=3,9),IAP(9)                                          FPR00520
      END FILE ITMP                                                     FPR00530
      REWIND ITMP                                                       FPR00540
10    READ (ITMP) (IAP(I),I=1,5),TAP(1),IAP(6),TAP(2),IAP(7),IAP(8),(TAPFPR00550
     2(I),I=3,9),IAP(9)                                                 FPR00560
      IF (IAP(1).EQ.IFLAG) GO TO 20                                     FPR00570
      WRITE (IP,200) (IAP(I),I=1,5),TAP(1),IAP(6),TAP(2),IAP(7),IAP(8),(FPR00580
     2TAP(I),I=3,9),IAP(9)                                              FPR00590
      GO TO 10                                                          FPR00600
20    KKK=0                                                             FPR00610
      NOSER=200                                                         FPR00620
      IF (N3.EQ.0) GO TO 40                                             FPR00630
C*******************************************************************FPR00640
C**   MASS WAS GIVEN IN ENGLISH UNITS                              **FPR00650
C**   CONVERT TO GRAMS                                             **FPR00660
C*******************************************************************FPR00670
      DO 30 I=1,NPRT                                                    FPR00680
      TRMASS(I)=TRMASS(I)*(1.D0/453.59237D0)                            FPR00690
      APPMAS(I)=APPMAS(I)*(1.D0/453.59237D0)*1000.0D0                   FPR00700
      CORRB(I)=CORRB(I)*(1.D0/453.59237D0)*1000.0D0                     FPR00710
      UNCERT(I)=UNCERT(I)*(1./453.59237)                                FPR00720
      VOLPRT(I)=VOLPRT(I)*.06102374                                     FPR00730
30    CONTINUE                                                          FPR00740
C*******************************************************************FPR00750
C**   MASS WAS GIVEN IN METRIC UNITS                               **FPR00760
C*******************************************************************FPR00770
40    IF (NPRT.EQ.1) GO TO 80                                           FPR00780
      DO 50 I=1,NPRT                                                    FPR00790
      TEMPAR(I)=TRMASS(I)                                               FPR00800
      NNP(I)=I                                                          FPR00810
50    CONTINUE                                                          FPR00820
      NNN=NPRT-1                                                        FPR00830
      DO 70 I=1,NNN                                                     FPR00840
      IP1=I+1                                                           FPR00850
      DO 70 J=IP1,NPRT                                                  FPR00860
      IF (TEMPAR(I)-TEMPAR(J)) 70,70,60                                 FPR00870
60    TEMP=TEMPAR(I)                                                    FPR00880
      TEMPAR(I)=TEMPAR(J)                                               FPR00890
      TEMPAR(J)=TEMP                                                    FPR00900
      TEMP=NNP(I)                                                       FPR00910
      NNP(I)=NNP(J)                                                     FPR00920
      NNP(J)=TEMP                                                       FPR00930
70    CONTINUE                                                          FPR00940
80    NN=1                                                              FPR00950
      IF (NPRT.NE.1) GO TO 90                                           FPR00960
      NNP(1)=1                                                          FPR00970
90    IPAGE=IPAGE+1                                                     FPR00980
      WRITE (IW,260) (B1(K),K=1,65),IPAGE                               FPR00990
      WRITE (IW,270) (B2(K),K=1,65),(IDATE(K),K=1,3)                    FPR01000
      WRITE (IW,280) (B3(K),K=1,65)                                     FPR01010
      WRITE (IW,290) (B7(K),K=1,18)                                     FPR01020
      IPGCT=8                                                           FPR01030
      IF (NN.EQ.2) GO TO 110                                            FPR01040
      IF (NN.EQ.3) GO TO 160                                            FPR01050
      JA=1                                                              FPR01060
      JB=12                                                             FPR01070
      IF (KKK.EQ.1) GO TO 100                                           FPR01080
      CALL TEXTS1                                                       FPR01090
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      KKK=1                                                              FPR01100
100   CONTINUE                                                           FPR01110
      IPAGE=IPAGE+1                                                      FPR01120
      WRITE (IW,260) (B1(K),K=1,65),IPAGE                                FPR01130
      WRITE (IW,270) (B2(K),K=1,65),(IDATE(K),K=1,3)                     FPR01140
      WRITE (IW,280) (B3(K),K=1,65)                                      FPR01150
      WRITE (IW,290) (B7(K),K=1,18)                                      FPR01160
      CALL TEXTS2                                                        FPR01170
      NN=2                                                               FPR01180
      GO TO 90                                                           FPR01190
110   CALL CHKLN (4)                                                     FPR01200
      WRITE (IW,210)                                                     FPR01210
      NN=3                                                               FPR01220
      CALL CHKLN (4)                                                     FPR01230
      IF (N3.EQ.0) GO TO 120                                             FPR01240
      WRITE (IW,300)                                                     FPR01250
      GO TO 130                                                          FPR01260
120   WRITE (IW,220)                                                     FPR01270
130   DO 150 J=1,NPRT                                                    FPR01280
      NNPP=NPRT+1-J                                                      FPR01290
      I=NNP(NNPP)                                                        FPR01300
      CALL CHKLN (1)                                                     FPR01310
      IF (N3.EQ.0) GO TO 140                                             FPR01320
C*********************************************************************FPR01330
C**   CONVERT DOUBLE PRECISION VALUE TO FLOATING POINT                **FPR01340
C*********************************************************************FPR01350
      CALL DPFD (TRMASS(I),TRMASX,15,11)                                 FPR01360
      WRITE (IW,310) (AITEM(IU,I),IU=1,5),TRMASX,UNCERT(I),VOLPRT(I),COEFPR01370
     2PRT(I)                                                             FPR01380
      GO TO 150                                                          FPR01390
140   CALL DPFD (TRMASS(I),TRMASX,15,8)                                  FPR01400
      WRITE (IW,230) (AITEM(IU,I),IU=1,5),TRMASX,UNCERT(I),VOLPRT(I),COEFPR01410
     2PRT(I)                                                             FPR01420
150   CONTINUE                                                           FPR01430
      GO TO 90                                                           FPR01440
160   CALL CHKLN (1)                                                     FPR01450
      IF (N3.EQ.0) GO TO 170                                             FPR01460
      WRITE (IW,320)                                                     FPR01470
      GO TO 180                                                          FPR01480
170   WRITE (IW,240)                                                     FPR01490
180   DO 190 J=1,NPRT                                                    FPR01500
      NNPP=NPRT+1-J                                                      FPR01510
      I=NNP(NNPP)                                                        FPR01520
      CALL DPFD (APPMAS(I),AAAMAS,13,5)                                  FPR01530
      CALL DPFD (CORRB(I),BBBMAS,13,5)                                   FPR01540
      CALL CHKLN (1)                                                     FPR01550
      WRITE (IW,250) (AITEM(IU,I),IU=1,5),AAAMAS,BBBMAS                  FPR01560
190   CONTINUE                                                           FPR01570
      WRITE (IW,330)                                                     FPR01580
      RETURN                                                             FPR01590
C*********************************************************************FPR01600
C**   FORMAT STATEMENTS                                               **FPR01610
C*********************************************************************FPR01620
200   FORMAT (3I2,I2,I3,F11.5,I3,F9.5,I2,I3,2F5.2,F6.2,F5.2,F7.4,F4.1,  FPR01630
     2 F6.4,I2,1H3)                                                      FPR01640
210   FORMAT (//20X,7HTABLE 1//)                                         FPR01650
220   FORMAT (/24X,4HMASS,8X,11HUNCERTAINTY,2X,9HVOL AT 20,2X,           FPR01660
     2 11HCOEF OF EXP/5X,4HITEM,16X,3H(G),13X,3H(G),6X,5H(CM3)/)         FPR01670
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230   FORMAT (2X,5A3,1X,15A1,1X,F13.8,1X,F10.5,1X,F8.6)                    FPR01680
240   FORMAT (/2X,4HITEM,18X,22HCOR.A (MG)  COR.B (MG)/)                   FPR01690
250   FORMAT (2X,5A3,1X,13A1,1X,13A1)                                      FPR01700
260   FORMAT (1H1,65A1,4HPAGE,I3)                                          FPR01710
270   FORMAT (1X,65A1,I2,1H/I2,1H/I2)                                      FPR01720
280   FORMAT (1X,65A1)                                                     FPR01730
290   FORMAT (1X,11HTEST NUMBER,2X,18A1//)                                 FPR01740
300   FORMAT (/24X,4HMASS,8X,11HUNCERTAINTY,2X,9HVOL AT 20,2X,             FPR01570
     2 11HCOEF OF EXP/5X,4HITEM,15X,4H(LB),12X,4H(LB),6X,5H(IN3)/)         FPR01760
310   FORMAT (2X,5A3,1X,15A1,1X,F13.11,1X,F10.6,1X,F8.6)                   FPR01770
320   FORMAT (12X,4HITEM,8X,5HCOR.A,7X,5HCOR.B/23X,10H(MICRO-LE),3X,       FPR01780
     2 10H(MICRO-LE))                                                     FPR01790
330   FORMAT (1H1)                                                         FPR01800
      END                                                                  FPR01810
--- TEXTS1 SUBPROGRAM ---
      SUBROUTINE TEXTS1                                                   TS100010
C*************************************************************************TS100020
C**   SUBROUTINE OF THE NATIONAL BUREAU OF STANDARDS MASS CALIBRATION **TS100030
C**   PROGRAM  VERSION OF SEPT.10,1971     WRITTEN BY R.C.RAYBOLD      **TS100040
C**   AND MRS.R.N.VARNER                                               **TS100050
C**   PRINT FIRST OF LAST TWO PAGES OF REPORT                          **TS100060
C**   MODIFIED BY R. N. VARNER SEPT 1979                               **TS100070
C*************************************************************************TS100080
      COMMON/UNITIO/IR,IW,IP,IPL,ITMP                                     TS100090
      WRITE (IW,10)                                                       TS100100
      WRITE (IW,20)                                                       TS100110
      WRITE (IW,30)                                                       TS100120
      WRITE (IW,40)                                                       TS100130
      WRITE (IW,50)                                                       TS100140
      WRITE (IW,60)                                                       TS100150
      WRITE (IW,70)                                                       TS100160
      WRITE (IW,80)                                                       TS100170
      WRITE (IW,90)                                                       TS100180
      WRITE (IW,100)                                                      TS100190
      RETURN                                                              TS100200
C*************************************************************************TS100210
C**  FORMAT STATEMENTS                                                  **TS100220
C*************************************************************************TS100230
10    FORMAT (1X,36H                SUMMARY                 ,             TS100240
     236H      THE   ESTIMATED   MASS  VALUES/                            TS100250
     31X,36H                                   ,                         TS100260
     436H  LISTED IN TABLE II ARE BASED ON AN/                             TS100270
     51X,36H    FOR  CONVENIENCE,  THE RESULTS  ,                        TS100280
     636H  IMPLICIT TREATMENT OF DISPLACEMENT/                           TS100290
     71X,36HOF THIS  WORK  ARE  SUMMARIZED  IN  ,                        TS100300
     836H  VOLUMES.  E.G., 'APPARENT   MASS',/                           TS100310
     91X,36HTABLES   I  AND  II.   THE  VALUES  ,                        TS100320
     *36H  'APPARENT   MASS  VERSUS   BRASS',)                           TS100330
20    FORMAT (1X,36HASSIGNED ARE WITH REFERENCE TO THE  ,                 TS100340
     236H  'APPARENT   MASS  VERSUS   DENSITY/                           TS100350
     31X,36HSTANDARDS IDENTIFIED ON  THE  DATA  ,                        TS100360
     436H  8.0'.  THE VALUES  ARE  LISTED  AS/                           TS100370
     51X,36HSHEETS.  THE UNCERTAINTY FIGURE IS  ,                        TS100380
     636H  CORRECTIONS TO BE APPLIED  TO  THE/                           TS100390
     71X,36HAN   EXPRESSION   OF  THE  OVERALL  ,                        TS100400
     836H  LISTED  NOMINAL  VALUE (A POSITIVE/                           TS100410
     91X,36HUNCERTAINTY USING  THREE  STANDARD  ,                        TS100420
     *36H  CORRECTION INDICATES THAT THE MASS)                           TS100430
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30    FORMAT (1X,36HDEVIATIONS  AS  A  LIMIT  TO  THE  ,                TS100440
     236H  IS LARGER THAN THE STATED NOMINAL/                           TS100450
     31X,36HEFFECT OF RANDOM ERRORS OF THE  ,                           TS100460
     436H  VALUE  BY  THE  AMOUNT  OF  THE/                             TS100470
     51X,36HMEASUREMENT  ASSOCIATED WITH THE  ,                         TS100480
     636H  CORRECTION).  THESE  VALUES  ARE/                            TS100490
     71X,36HMEASUREMENT PROCESSES. THE MAGNI-  ,                        TS100500
     836H  COMPUTED  FROM THE VALUES BASED ON/                          TS100510
     91X,36HTUDE  OF  SYSTEMATIC  ERRORS  FROM  ,                       TS100520
     *36H  AN EXPLICIT TREATMENT OF DISPLACE-)                          TS100530
40    FORMAT (1X,36HSOURCES  OTHER  THAN  THE  USE  OF  ,               TS100540
     236H  MENT VOLUMES USING THE FOLLOWING/                            TS100550
     31X,36HACCEPTED  VALUES  FOR  CERTAIN  ,                           TS100560
     436H  DEFINING  RELATIONS  AND  ARE/                               TS100570
     51X,36HSTARTING  STANDARDS ARE CONSIDERED  ,                       TS100580
     636H  UNCERTAIN BY THE AMOUNT  SHOWN  IN/                          TS100590
     71X,36HNEGLIGIBLE.  IT  SHOULD  BE  NOTED  ,                       TS100600
     836H  TABLE I.                          /                          TS100610
     91X,36HTHAT  THE MAGNITUDE OF THE UNCER-  ,                        TS100620
     *36H                                    )                          TS100630
50    FORMAT (1X,36HTAINTY REFLECTS THE PERFORMANCE OF  ,               TS100640
     236H      THE  ADJUSTMENT  OF WEIGHTS TO/                          TS100650
     31X,36HTHE MEASUREMENT  PROCESS  USED  TO  ,                       TS100660
     436H  MINIMIZE THE DEVIATION FROM NOMI-/                           TS100670
     51X,36HESTABLISH  THESE VALUES.  THE MASS  ,                       TS100680
     636H  NAL ON THE BASIS OF 'NORMAL BRASS'/                          TS100690
     71X,36HUNIT,  AS  REALIZABLE  IN  ANOTHER  ,                       TS100700
     836H  (IN  ACCORDANCE WITH COR. A BELOW)/                          TS100710
     91X,36HMEASUREMENT  PROCESS,  WILL  BE  ,                          TS100720
     *36H  IS WIDESPREAD IN THIS COUNTRY  AND)                          TS100730
60    FORMAT (1X,36HUNCERTAIN BY AN AMOUNT WHICH IS  A  ,               TS100740
     236H  IN  MANY  PARTS  OF  THE  WORLD./                            TS100750
     31X,36HCOMBINATION  OF THE UNCERTAINTY OF  ,                       TS100760
     436H  VALUES STATED ON EITHER BASIS  ARE/                          TS100770
     51X,36HTHIS PROCESS AND  THE  PROCESS  IN  ,                       TS100780
     636H  INTERNALLY  CONSISTENT  AND/                                 TS100790
     71X,36HWHICH THESE STANDARDS ARE USED.  ,                          TS100800
     836H  DEFINITE.  THERE  IS,  HOWEVER,  A/                          TS100810
     91X,36H                                 ,                          TS100820
     *36H  SYSTEMATIC  DIFFERENCE BETWEEN THE)                          TS100830
70    FORMAT (1X,36H    THE  ESTIMATED  MASS  VALUES  ,                  TS100840
     236H  VALUES ASSIGNED ON EACH BASIS, THE/                          TS100850
     31X,36HLISTED IN TABLE I ARE BASED ON  AN  ,                       TS100860
     436H  VALUE ON  THE  BASIS  OF  'DENSITY/                          TS100870
     51X,36HEXPLICIT TREATMENT OF DISPLACEMENT  ,                       TS100880
     636H  8.0'  BEING 7 MICROGRAMS/GRAM LAR-/                          TS100890
     71X,36HVOLUMES,  E.G.,  'TRUE MASS',  'MASS  ,                     TS100900
     836H  GER THAN THE VALUE ON THE BASIS OF/                          TS100910
     91X,36HIN VACUO',  MASS  IN  THE  NEWTONIAN  ,                     TS100920
     *36H  NORMAL  BRASS.  THIS  SYSTEMATIC)                            TS100930
80    FORMAT (1X,36HSENSE.  THE  DISPLACEMENT  VOLUME  ,                TS100940
     236H  DIFFERENCE  IS  CLEARLY DETECTABLE/                          TS100950
     31X,36HASSOCIATED  WITH  EACH  VALUE  IS  ,                        TS100960
     436H  ON MANY DIRECT READING BALANCES.  /                          TS100970
     51X,36HLISTED  AS  WELL  AS  THE VOLUMETRIC  ,                     TS100980
     636H                                    /                          TS100990
     71X,36HCOEFFICIENT OF  EXPANSION.  THESE  ,                        TS101000
     836H      CORRECTION A - 'APPARENT  MASS/                          TS101010
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     91X,36HVALUES  SHOULD  BE  USED, TOGETHER  ,                          TS101020
     *36H  VERSUS  BRASS' OR  'WEIGHT  IN AIR)                             TS101030
90    FORMAT (1X,36HWITH  APPROPRIATE  CORRECTION  FOR  ,                  TS101040
     236H  AGAINST BRASS' IS DETERMINED  BY  A/                            TS101050
     31X,36HTHE  BUOYANT  EFFECTS  OF  THE  ,                              TS101060
     436H  HYPOTHETICAL  WEIGHING  OF  THE/                                TS101070
     51X,36HENVIRONMENT, TO ESTABLISH CONSIST-  ,                          TS101080
     636H  WEIGHT AT 20 CELSIUS IN AIR HAVING/                             TS101090
     71X,36HENT MASS VALUES FOR OBJECTS  WHICH  ,                          TS101100
     836H  A DENSITY OF 1.2  MG/CM3,  WITH  A/                             TS101110
     91X,36HDIFFER  SIGNIFICANTLY  IN  DENSITY  ,                          TS101120
     *36H  (NORMAL  BRASS)  STANDARD HAVING A)                             TS101130
100   FORMAT (1X,36HAND/OR FOR MEASUREMENTS WHICH MUST                      TS101140
     236H  DENSITY OF 8.4 G/CM3 AT 0  CELSIUS/                             TS101150
     31X,36HBE MADE IN DIFFERING ENVIRONMENTS.  ,                          TS101160
     436H  WHOSE  COEFFICIENT  OF  VOLUMETRIC/                             TS101170
     51X,36HTHE RELATION  1LB AVDP=.45359237KG  ,                          TS101180
     636H  EXPANSION IS 0.000054  PER  DEGREE/                             TS101190
     71X,36HIS USED AS REQUIRED.                ,                          TS101200
     836H  CELSIUS,  AND WHOSE VALUE IS BASED/                             TS101210
     91X,36H                                    ,                          TS101220
     *36H                                    )                             TS101230
      END                                                                  TS101240
--- TEXTS2 SUBPROGRAM ---
      SUBROUTINE TEXTS2                                                    TS200010
C*************************************************************************TS200020
C**   SUBROUTINE OF THE NATIONAL BUREAU OF STANDARDS MASS CALIBRATION **TS200030
C**   PROGRAM  VERSION OF SEPT.10,1971     WRITTEN BY R.C.RAYBOLD     **TS200040
C**   AND MRS.B.N.VARNER                                               **TS200050
C**   PRINT LAST PAGE OF REPORT                                        **TS200060
C**   MODIFIED BY R. N. VARNER SEPT 1979                               **TS200070
C*************************************************************************TS200080
      COMMON/UNITIO/IR,IW,IP,IPL,ITMP                                      TS200090
      WRITE (IW,10)                                                        TS200100
      WRITE (IW,20)                                                        TS200110
      RETURN                                                               TS200120
C*************************************************************************TS200130
C**      FORMAT STATEMENTS                                               **TS200140
C*************************************************************************TS200150
10    FORMAT (                                                             TS200160
     236H                                    /                             TS200170
     31X,36HON ITS  TRUE  MASS  OR  WEIGHT  IN  ,                          TS200180
     436H WEIGHT, IN AIR HAVING A DENSITY OF /                             TS200190
     51X,36HVACUO.                           ,                             TS200200
     636H 1.2 MG/CM3, WITH A STANDARD HAVING /                             TS200210
     71X,36H                                 ,                             TS200220
     836H A  DENSITY  OF  8.0  G/CM3  AT 20  )                             TS200230
20    FORMAT (1X,36H    CORRECTION  B - 'APPARENT MASS                     TS200240
     236H CELSIUS,  AND WHOSE VALUE IS BASED /                             TS200250
     31X,36HVERSUS DENSITY 8.0' IS  DETERMINED  ,                          TS200260
     436H ON ITS  TRUE  MASS  OR  WEIGHT  IN /                             TS200270
     51X,36HEY  A HYPOTHETICAL WEIGHING OF THE  ,                          TS200280
     636H VACUO.                             )                             TS200290
      END                                                                  TS200300
--- DPFD SUBPROGRAM ---
      SUBROUTINE DPFD (A,B,N,D)                                            DPF00010
C*************************************************************************DPF00020
C**   SUBROUTINE OF THE NATIONAL BUREAU OF STANDARDS MASS CALIBRATION **DPF00030
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C**   PROGRAM  VERSION OF SEPT.10.1971     WRITTEN BY P.C.RAYFIELD     **DPF00040
C**   AND MRS.R.N.VARNER                                               **DPF00050
C**   MODIFIED BY R. N. VARNER SEPT 1979                               **DPF00060
C*****************************************************************DPF00070
C**   WRITTEN BY CLAYTON ALBRIGHT OF CSD                               **DPF00080
C**   A ROUTINE TO CONVERT A DOUBLE PRECISION NUMBER TO A BLOCK OF     **DPF00090
C**   CHARACTERS WHICH WHEN OUTPUT WITH SUITABLE FORMAT (EG. 30A1)     **DPF00100
C**   WILL YIELD THE NUMBER IN F-TYPE FORMAT (NO EXPONENT).            **DPF00110
C**    THE OUTPUT NUMBER WILL BE RIGHT ADJUSTED IN THE FIELD           **DPF00120
C**                                                                    **DPF00130
C**   A = THE DOUBLE PRECISION NUMBER TO BE CONVERTED                  **DPF00140
C**   B = A BLOCK OF N WORDS TO CONTAIN THE RESULTS. THE CHARACTERS    **DPF00150
C**   ARE STORED ONE TO A WORD IN B, LEFT ADJUSTED IN THE WORD         **DPF00160
C**   N = FIELD WIDTH DESIRED                                          **DPF00170
C**   D = NUMBER OF PLACES DESIRED TO RIGHT OF DECIMAL POINT.          **DPF00180
C**                                                                    **DPF00190
C**   IF NUMBER OVERFLOWS FIELD WIDTH, FIELD IS FILLED WITH *'S        **DPF00200
C**    IF UNDERFLOW OCCURS RESULT WILL BE ZERO                         **DPF00210
C**                                                                    **DPF00220
C**   *RESTRICTION- AT LEAST ONE CHARACTER POSITION MUST BE ALLOWED    **DPF00230
C**                 FOR SIGN REGARDLESS OF + OR -. IF USER OBJECTS     **DPF00240
C**                 TO THIS RESTRICTION, HE NEED ONLY USE THE          **DPF00250
C**                 RESULTING OUTPUT CHARACTERS BEGINNING AT B(2)      **DPF00260
C**                 INSTEAD OF B(1).                                   **DPF00270
C**                                                                    **DPF00280
C*****************************************************************DPF00290
C**   TYPE STATEMENTS                                                  **DPF00300
C*****************************************************************DPF00310
      INTEGER B,D                                                       DPF00320
      DOUBLE PRECISION A,X                                              DPF00330
C*****************************************************************DPF00340
C**   DIMENSION STATEMENT                                              **DPF00350
C*****************************************************************DPF00360
      DIMENSION B(1)                                                    DPF00370
      COMMON /DPFDVL/ KFD(18)                                           DPF00380
      IF (D+1.GE.N) GO TO 60                                            DPF00390
C*****************************************************************DPF00400
C**   ROUND THE NUMBER AT DESIRED DECIMAL PLACE                        **DPF00410
C*****************************************************************DPF00420
      X=DABS(A)+.5*10.**(-D)                                            DPF00430
      MM=N-D-2                                                          DPF00440
      X=X*10.**(-MM)                                                    DPF00450
      IF (X.GE.1.D0) GO TO 60                                           DPF00460
      IF (X.GE.0.1D0.AND.A.LT.0.D0) GO TO 60                            DPF00470
      MM=MM+1                                                           DPF00480
      DO 10 I=1,MM                                                      DPF00490
      B(I)=KFD(11)                                                      DPF00500
      K=IDINT(X*10.D0)                                                  DPF00510
      X=X*10.-FLOAT(K)                                                  DPF00520
      IF (K.NE.0) GO TO 20                                              DPF00530
10    CONTINUE                                                          DPF00540
      I=MM                                                              DPF00550
C*****************************************************************DPF00560
C**    PREFIX MINUS SIGN IF A NEGATIVE                                 **DPF00570
C*****************************************************************DPF00580
20    IF (A.LT.0.D0) B(I)=KFD(12)                                       DPF00590
      IF (I.EQ.MM) GO TO 40                                             DPF00600
C*****************************************************************DPF00610
```

```
C**     CONVERT INTEGER PART                                          **DPF00620
C*************************************************************************DPF00630
      I=I+1                                                            DPF00640
      DO 30 J=I,MM                                                     DPF00650
      B(J)=KFD(K+1)                                                    DPF00660
      K=IDINT(X*10.D0)                                                 DPF00670
30    X=X*10.-FLOAT(K)                                                 DPF00680
C*************************************************************************DPF00690
C**     STORE DECIMAL POINT                                           **DPF00700
C*************************************************************************DPF00710
40    MM=MM+2                                                          DPF00720
      B(MM-1)=KFD(13)                                                  DPF00730
C*************************************************************************DPF00740
C**     CONVERT FRACTIONAL PART                                       **DPF00750
C*************************************************************************DPF00760
      DO 50 I=1,D                                                      DPF00770
      B(MM)=KFD(K+1)                                                   DPF00780
      MM=MM+1                                                          DPF00790
      K=IDINT(X*10.D0)                                                 DPF00800
50    X=X*10.-FLOAT(K)                                                 DPF00810
      RETURN                                                           DPF00820
C*************************************************************************DPF00830
C**     STORE *'S IF OVERFLOW                                         **DPF00840
C*************************************************************************DPF00850
60    DO 70 I=1,N                                                      DPF00860
70    B(I)=KFD(14)                                                     DPF00870
      RETURN                                                           DPF00880
      END                                                              DPF00890
--- CHKLN SUBPROGRAM ---
      SUBROUTINE CHKLN (N)                                             CHK00010
C*************************************************************************CHK00020
C**   SUBROUTINE TO CHECK BEGINNING OF A NEW PAGE                     **CHK00030
C**   ADDED BY R. N. VARNER SEPT 1979                                 **CHK00040
C*************************************************************************CHK00050
      COMMON /PRT2/ IPAGE,NOSER,IPGCT                                  CHK00060
      COMMON /UNITIC/ IR,IW,IP,IPL,ITMP                                CHK00070
      IF (IPGCT+N.GT.IPL) CALL PGCONT                                  CHK00080
      IPGCT=IPGCT+N                                                    CHK00090
      RETURN                                                           CHK00100
      END                                                              CHK00110
```

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15. SUPPLEMENTARY NOTES

☐ Document describes a computer program, SF-185, FIPS Software Summary, is attached.

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

This report describes the FORTRAN computer program used to generate a comprehensive report covering the sequence of operations used to assign mass values to weights submitted to the National Bureau of Standards for calibration. The assignment of these values is accomplished by the method of least squares analysis of the observation of differences between test items and reference items having the same or nearly same density and nominal size. The calculations are defined and the various weighing method options are given. To assist the user, a detailed description of the input data, an input list of error messages, a listing of a sample test case and a listing of the output resulting from the use of the sample test case are given. To assist in the implementation of the computer program, a flow chart, a description of each subprogram, a cross-reference of labeled COMMON, a list of DOUBLE PRECISION variables, a list of EQUIVALENCED variables and other pertinent information is given.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Calibration report; correction to mass measurements; error checking; FORTRAN program; least squares solution; mass calibration; mass measurement.

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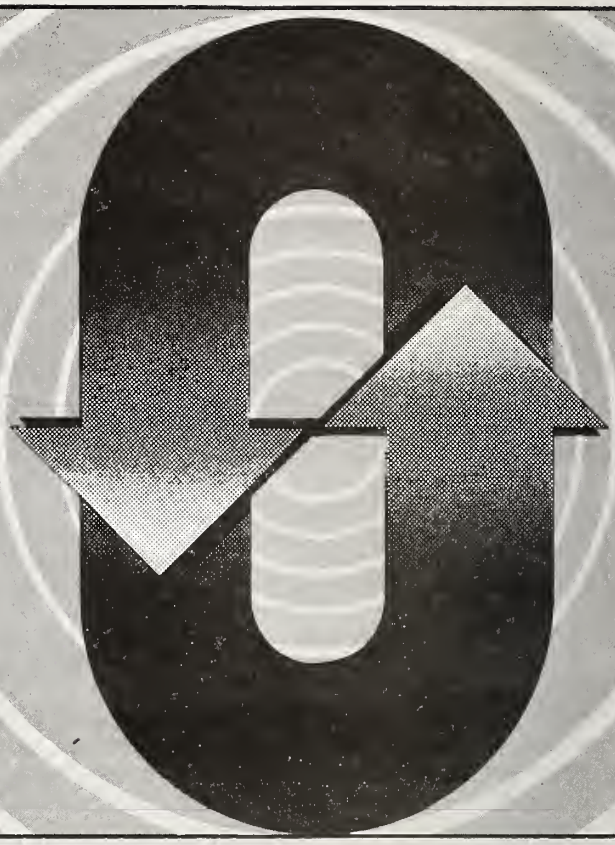
Waste Heat Management Guidebook



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